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# Local interactions between rental and real estate housing markets

Yohann Trouve

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**Yohann TROUVE**

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# **Les interactions locales entre le marché de la location et le marché de l'achat immobilier.**

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# Université Lumière Lyon 2

L'Ecole Doctorale 486 Sciences Economiques et de Gestion

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## **Local interactions between rental and real-estate housing markets.**

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par

Yohann Trouvé-Sargison

Sciences économiques

Sous la direction de Florence Goffette-Nagot.

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# Introduction

The housing market consists of two main segments, the rental market and the sales market. Although these two markets operate differently, prices on the two markets are naturally subject to reciprocal interactions: the level of rents affects prices of sale, but prices on the sales market have an impact on rents. On the first approach, the rents are convertible into a selling price by a capitalization formula. However, it is possible, and empirically observed, that imbalances exist between the two markets. Thus, the relative dynamics of both prices and rents can vary over time, and also in the space of an urban area.

How are prices in the two markets (sale and rental) related? How does one affect the other? Is the relationship between the two prices homogeneous in space? Why is it that some neighbourhoods of an agglomeration have rents that are too low in relation to purchase prices? These questions are of particular interest to local policy actors in housing, in a context of strong tensions on the housing market as is the case in the Lyon conurbation. In particular, they are strongly linked to policies aimed at supporting the supply of housing or the level of market rents.

Given the high proportion of social housing in the French housing stock (around 20% in large urban areas), another question that must be asked is that of the interactions between supply and demand of social housing and private rental rents. If it turns out that the supply of social housing affects levels of rents in the private sector, then the public authority, by deciding on the location of social housing could take into account its influence on the private housing market.

Therefore it is fundamental for local authorities and, in this case, for the Greater Lyon, to better understand the interactions between the different segments of the housing market at a local level. However, for convenience, the economic analysis of the the housing market often focuses on one of the two markets: private rental or sale. It is useful, both from the point of view of a local authority such as Greater Lyon and from the point of view of academic research, to develop research on the interactions between the different market segments of housing.

## 1 Research question

### 1.1 The relation between price and rents and the local rent to price ratios

The research question of the thesis is related to the link between the rental sub market and the real estate sub market. One of our main goals is to investigate the local links between these two sub markets, an economics intuition that is in line with Case et Shiller (1990) findings in their seminal paper. The user cost theory was established to investigate more accurately what an individual should do in order to buy or to rent his dwelling. This theory is centered around non-arbitrage conditions that define the user cost of homeowners and renters. The definition of the user cost has been improved with several contributions. The tax system plays a role in the definition of the user cost because in most countries both submarkets are taxed differently. In France for example, homeowners pay both the rental tax and the property tax whereas renters only pay the rental tax. Such differential tax treatments must be accounted for in the definition of the user cost. In addition to the tax system, several key features are important in the definition of the user cost. The impact of the vacancy risk (Grégoir et al. 2010), the transactions costs, the opportunity of the down-payment demanded by banks for the loan (Sommer et al. 2013), the difference in interest rate are key features that can impact the user cost for either homeowners or renters.

The relationship between rental level and selling price level is a determinant of the return on rental investment. It is natural to question the variability of this return within an urban area, which can influence future investment behaviour and the supply of new housing. By estimating a sales price model that takes into account structural and location characteristics, it allows the purchase price to be predicted according to the characteristics of a dwelling. Such a model and the predictions derived from it make it possible to calculate, for rental housing, real estate returns as the sum of rental returns (ratio between the flows of rents received and the initial purchase price) and capital returns (real and annualized growth rate of prices between the purchase and sale of an apartment three years later). It is possible to observe whether there is a strong geographical and temporal variability in these rental yields.

### 1.2 Link between private and public housing markets

Another axis of research of this thesis focuses on the interactions between the supply of social housing and the price levels of private housing. The supply of social housing is likely to affect private prices and rents through two mechanisms. First, the establishment of new social housing changes the socio-demographic composition of a neighbourhood and is therefore likely to change the willingness to pay of households (tenants on the private market) for this district due to the existence of social

preferences. Social housing being built in a concentrated form, they also modify other attributes of the neighbourhood such as population density or urban landscape. The impact of such social housing is difficult to measure. We can only observe its effect when social dwellings are destroyed. As a result, the urban renewal programs can affect the composition of the population both through residents of destroyed and newly created housing, but also through changes in attractiveness of the neighbourhood that affect the occupancy of the entire housing stock. In doing so, the supply of housing can affect private rental prices. Thus, depending on the type of modification carried out, an increase or decrease in the supply of social housing in a neighbourhood has an ambiguous effect on its attractiveness and therefore on the prices of private rental housing in the neighbourhood. In addition, it can also be assumed that the construction of social housing, by modifying the supply of housing in the district in question, may have effects on private rental prices through a substitution effect.

### **1.3 The affordability issue and the impact on both sub-markets**

The last axis of research of this thesis concerns public policies aimed at providing affordable housing. The issue of affordable housing is not a new one, but it has seen a renewed interest in the aftermath of the economic crisis from both researchers and public policy makers. The prevalent aim of these policies is to promote the construction of housing, but more particularly housing for populations with moderate incomes. Several types of policies are put in place to promote the construction of these housing units, policies aimed at homeowners and policies aimed towards the rental market and thus towards landlords and tenants. In the third part of the thesis we will focus on the effect of two policies that target the promotion of housing construction, buy-to-let policies and free interest loan policies. These two public policies seek to help landlords provide low-cost housing and to help homeowners buy their first property. Both these policies have eligibility criterias that specifically ensure that housing is occupied by people with moderate incomes whilst being limited to new dwellings.

## **2 Context**

### **2.1 Brief housing context in France**

In France, in 2010 the entirety of the real estate was worth approximately 7.700 billion euros (Cornuel,2013). 70% of the real estate was owned by households and it was worth 70% of all their asset portofolio (Cornuel,2013). Among real estate owners, it is possible to distinguish two different main categories, homeowners and landlords.

Homeowners are defined by the fact that they live in the house that they own. There are 15.7 millions homeowners in France. Homeowners are remarkable in several ways. They are usually older



than the general population. In 2013 there were 74,4% of individuals that were homeowners and older than 65, whereas only 13,6% of individuals that were younger than 30 were also homeowners. Homeowners are likewise characterized by the fact that in most cases, their real estate capital is the large majority of the capital they own (Cornuel, 2013; Piketty, 2013).

Landlords do not live in their real estate, they provide shelter services to other individuals in exchange for a rent. In France Landlords represented in 2006 approximately 9.4% of the French households<sup>1</sup>. Landlords own approximately 4,665 millions dwellings, and among those dwellings 724 000<sup>1</sup> are reported as vacant.

In 2013 there were 11.4 millions households that rented their dwelling. Among these renters, 6% rented furnished dwellings whereas the other 94% rented unfurnished dwellings. Renters in France are characterized by their age, the younger an individuals is, the higher the probability he has of being a renter. For example, within the French population, 79% of couples are renters when either one or both individuals is 30 or younger. In addition, the probability to be a renter is higher for individuals that are divorced or for single-parent families. Nearly all single-parents (97%) that are 30 or younger are renters. Renters also differ from homeowners in their spatial lay-out. Most renters are located in urban areas<sup>2</sup>.

In France, the share of individuals owning their own dwelling was equal to 57.9% in 2013. This proportion has slightly increased during the last 30 years<sup>3</sup>. The proportion of homeowners differs across the life cycle of individuals and according to where they live. On the one hand, the youngest individuals are usually the less likely to be homeowners whereas the older an individual gets, the higher the probability he has of being a homeowner. On the second-hand, the share of homeowners and renters differs also greatly within the French territory, the share of homeowners being significantly higher in the countryside. Cornuel (2013). claims that individuals first rent a flat and in a second step then buy a house. His argument gains in validity when he highlights that the countryside is also characterized by a larger share of older individuals than in metropolitan areas.

## 2.2 Brief housing context in Lyon

The Lyon conurbation is made up of 68 municipalities (59 municipalities and 9 districts). These municipalities are exposed on the figure 1. In this agglomeration live 1 381 349 people. This population grew by an average of 1.1% every year between 2009 and 2016. While in France there are a greater

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<sup>1</sup>National housing survey of 2006. This survey is conducted by the national institute for statistics and economic studies, abbreviated INSEE in French.

<sup>2</sup>93% of renters are located in urban areas, as defined by the national institute for statistics and economic studies. These figures come from the 2017 report "Les conditions de logement en France" written by the national institute for statistics and economic studies.

<sup>3</sup>In 2013 the share of Homeowners was 57.9%, whereas it was 52.3% in 1984

number of homeowners than tenants, within the Lyon urban area the opposite is true. According to INSEE<sup>4</sup>, there are 44% of homeowners living in the urban area while there are 56% of tenants. The total number of housing units in the agglomeration was approximately 695,000 in 2016. Of this total, 565,000 are apartments, while 120,000 are recorded as houses. In addition, approximately 51,541 of these dwellings were vacant at the time of the census. Of all its dwellings, 3- and 4-room dwellings are the most numerous (about 166,000 and 150,000) while one-room dwellings are the rarest (about 60,000). More than half of the housing units in Greater Lyon are buildings built during the period stemming from 1946 to 1990 (55.8%).

## 3 Method and Data used

### 3.1 Method

In this thesis we use both empirical and theoretical analyses. In the first chapter we use theoretical concepts of the non-arbitrage conditions in order to determine how the rent to price ratios are set. To do this, we express each of the household user costs, for homeowners and for renters in order to compare them. With this analysis we are able to write the equation to highlight which variables have an influence on the rent to price ratio at the local level.

In chapter 3 we develop a theoretical model to show how the housing market reacts when the constraints on two public policies are relaxed, the buy-to-let policy and the free interest loan policy. We then propose a simulation exercise to highlight the main implications of relaxing the eligibility constraints of the two public policies.

In addition to theoretical analyses, we also carry out empirical analyses. In each chapter of this thesis, we use the hedonic price method. In order to predict the prices of housing for purchase and rental in the first chapter, or to estimate the causal effect of public policy, we estimate the price of housing by taking into account its characteristics.

In addition, in Chapters 2 and 3 we use the double difference method. We use this method to be able to estimate the causal effect of public policies. The properties of these policies are conducive to the use of this method. They concern a portion of home sales and are set up on a specific date.

Finally, we also use the discontinuity regression method in Chapter 2, which we use because we exploit a characteristic specific to the SRU law. Indeed, this policy is subject to a threshold effect. We exploit this threshold through a regression on discontinuity. This method allows us to observe the causal effect of social housing construction on small municipalities.

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<sup>4</sup>The data come from surveys RP2011 and RP2016. These surveys are conducted by the national institute for statistics and economic studies.

Figure 1: Map of all municipalities in the Grand Lyon area in 2014.



## 3.2 Data

We use two main data sources, namely data from notaries and data from the local rent observatory.

The database on sales is compiled by notaries and is called PERVAL. All sales that require registration by notaries are mostly recorded in the PERVAL database. This database includes a lot of information on the characteristics of dwellings. For the empirical analyses conducted in this thesis we have data for the Greater Lyon area and from 2004 to 2016.

The rent database comes from the local rent observatory, that compiles the collection of databases belonging to the real estate agencies of the agglomeration. The objective of the observatory is to ensure that the data follows the same methodology. One of the objectives of the local observatories is to ensure that this methodology is the same throughout France. The rent database that is mobilized in this work concerns rents that exist in 2014 in the Greater Lyon area.

# 4 Overview of the chapters

## 4.1 Chapter 1

The first chapter of this thesis attempts to observe whether rent to price ratios within an urban area vary and seeks to explain the discrepancies between rent to price ratios, if they exist.

To answer this question, this contribution is divided in two main parts. The first part concerns the computation of rent to price ratios in the agglomeration. The second part seeks to find what theoretical arguments can justify why different rent to price ratios exist within an agglomeration and to test these theoretical findings empirically.

The computation of the rent to price ratios is carried out in two steps. In this work two databases are used, one from notaries and which only concerns property sold, and the other from the local observatory of rents in Lyon, which only concerns rented property. With these two databases, we have quality information on a large number of individual housing units both rented and purchased in the Lyon area over the year 2014. However, it is not enough to have these two databases to be able to calculate the rent to price ratios, as rented and sold dwellings may differ in terms of characteristics. For this reason we propose to compute the rent of a purchased dwelling, and the purchase price of a rented dwelling. We break down the price (rent) of a property according to its characteristics in a first step. And in a second step we use these estimated coefficients to predict the price of a rented property (the rent of a purchased dwelling). This way we are able to compute rent to price ratios taking into account the problem of the specific characteristics of rented dwellings and purchased dwellings.

In the second part of this paper we seek to understand which theoretical arguments can explain why different rent to price ratios exist within the Lyon urban area. Three non-arbitrage relationships

are used to model the impact of certain variables that may explain the differences in the rent to price ratio. The elements highlighted are: the credit constraint, the vacancy rate, the amount of interest that can be deducted and the untaxed imputed rent of homeowners. The credit constraint has two effects, the first effect of the credit constraint is the effect of the interest rate. The second effect is related to the opportunity cost of building up sufficient savings to pay the required down-payment to obtain the loan. In the last part of this contribution we look for empirical evidence of the impact of these variables on rent to price ratios using proxies for the variables highlighted in the theoretical framework. Empirical results suggest that the vacancy rate has a positive influence on rent to price ratios whereas the tightening of the credit constraint seems to reduce the rent-to-price ratio. We also present evidence that as untaxed imputed rents become more significant, the ratio of rents to prices decreases.

## 4.2 Chapter 2

The second chapter of this thesis focuses on the relationship between the private housing market prices and the construction of social housing. The research question is as follows: Does the construction of social housing influence private housing prices?

To answer this question, we develop two empirical analyses. Each of the two analyses use the characteristics of the SRU to estimate causal effects. The first analysis uses the difference in difference method with a continuous treatment, while the second part of the analysis uses the regression on discontinuity method.

In the first part of this work we propose to use a feature of a French law ; the SRU law. The SRU law forces municipalities with more than 3500 inhabitants to build social housing until it represents 20% of the total quantity of housing in the municipality. At the time the law was enforced, many municipalities had social housing levels below the 20% required by law. In this first empirical contribution, we test for the impact of the SRU law on house prices using a double-difference method. The interaction term is constructed as the gap between the SRU objectives and the percentage of social housing in 2006. The results indicate that as the municipality's delay in achieving the SRU's objectives increases, it leads to an increase in the construction of social housing, and ultimately to a decrease in the municipality's housing prices.

In this contribution we carry out a second empirical study using another feature of the SRU. For a municipality to be subject to the 20 percent rule, it must be inhabited by more than 3500 people. Therefore, do this, we use a discontinuity regression method using the 3500 population threshold. We conduct our analysis on the price of housing in the municipalities just above and just below the threshold. The results of this second analysis suggest that the construction of social housing has had

a negative impact on housing prices in the municipalities with more than 3500 inhabitants.

These results indicate a negative impact of social housing construction in both analyses. But these two analyses do not deal with the same samples of dwellings. Indeed, the difference in difference regression deals with sales that take place in municipalities with more than 3500 inhabitants and with less than 20% of social housing. In the sample of this database, there are medium-sized municipalities and even several districts of Lyon. However, in the second analysis we voluntarily limit ourselves only to municipalities with a number of inhabitants close to 3500. Our contribution is therefore to highlight an unambiguous impact of social housing construction on large and small municipalities, as well as to shed light on the impact of social housing construction in France for public policy makers.

### 4.3 Chapter 3

In the first chapter we tried to measure how the rental and the real estate market influenced each other, whereas in the second chapter we tried to measure the impact of public housing construction on the private housing market. In this third chapter we attempt to observe the impact of policies facilitating the construction of affordable housing.

Indeed in France as well as in other Western countries, several policies have created incentives to encourage private actors to build affordable housing. This concern is not new. However, it has come to the forefront of the academic and public debate in the aftermath of the economic crisis. Today, there are several policies that encourage landlords to rent housing at moderate rents or policies that try to facilitate access to homeownership. Nevertheless, if these policies have already been studied, this chapter attempts to understand their combined impact on the private housing market. In particular, we try to show the impact of buy-to-let support policies and interest-free loans policies. To be able to separate the effect of one policy from the other, we use a particular feature of the buy-to-let support policy in France, the rent ceiling. To benefit from the buy-to-let support policy, rented dwellings must comply with a rent ceiling. This rent ceiling is not binding in some areas of the agglomeration while it is in others. This allows us to empirically isolate the specific effect of rental investment aid on prices.

The first step in our contribution is to design a theoretical model. This theoretical model highlights the effects of each of the two mechanisms, and also highlights how the housing market reacts when each of the two mechanisms is coupled with a rent control policy. There are two model predictions that we test in a second step. The first prediction is that in the absence of rent control, both mechanisms have the same qualitative effects. The second prediction of the model is that in the presence of rent control, the effect of the buy-to-let support policy is reinforced. On the second-hand market, rent control accentuates effect of the interest-free loan policy on prices, but it dampens the effect of the buy-to-let policy on second-hand housing prices.

The second step of this chapter is an empirical analysis. In this analysis we test whether the predictions of the previously developed model are valid. We implement two major regressions using the difference-in-difference method. In addition, we also use the triple difference method to take into account the differential impact of the implementation of rental ceilings. In order to extract the causal links between the different mechanisms and the impacts on housing prices, we use the reform of the PINEL law of October 2014.

The results indicate that the impact of the reform on new housing prices is positive. At the same time, the results indicate that the prices of second-hand dwellings are stable. The last step in our analysis is a triple difference method that indicates that new dwelling price growth is accelerated in the presence of binding rent control, while this rent control mitigates the decline in second-hand home prices.

## Chapter 1 :

# How to explain differences in rent-to-price ratios in the urban area ?

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### *Abstract*

The rent-to-price ratio is a measure commonly used to assess the profitability of the housing market. Empirical studies observe that the rent-to-price ratio is highly heterogeneous inside an urban area. However, most studies that explain spatial variations of the rent-to-price ratio use aggregated values to explain inter-metropolitan variations and cannot explain the intra-metropolitan heterogeneity of the rent-to-price ratios. This chapter aims to show that factors that vary inside the metropolitan area such as the vacancy risk, the untaxed imputed rent of homeowners or the tightness of the credit constraint are indeed important to properly foresee the housing market profitability. In this chapter, we first estimate hedonic prices for rental and owner-occupied housing units based on two databases on rents and transactions. This allows us to predict prices for rented housing units and rents for owner-occupied housing units and thus rent-to-price ratios at an individual level. In a second step, we determine which factors explain the heterogeneity in neighborhood-averaged rent-to-price ratios.

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## 1 Introduction

Agents, on the housing market, are either allowed to rent shelter services or buy housing capital. Even if those two sub-markets do not function in a similar fashion, they are nonetheless intimately linked. In other words, the market price level will impact the market rent level, and the market rent level will conversely impact the market price. Economic intuition would suggest that rents should be capitalized into prices, thus implying that any investor would be able to compute the price of a house according to its rent.

Our main goal in this chapter is to understand the link between the rental and buying markets on a local scale. Understanding the links between the rental and the buying markets require to consider three non-arbitrage conditions, which arise because agents are allowed to choose among several substitutes when choosing a housing. Firstly, the financial non-arbitrage condition exists because agents can choose to buy financial assets or housing capital, and should in equilibrium be indifferent between the two substitutes. Secondly, another non-arbitrage condition represents the indifference between owning and renting one's housing. Lastly, the spatial non-arbitrage condition refers to the choice of location: agents are indifferent between two different locations that represent two bundles of prices and amenities. These three non-arbitrage conditions are the mechanisms through which the two markets, namely rental and owner-occupied, are linked.

The economic intuition deriving from these three non-arbitrage conditions is that the rent-to-price ratio should be equal inside a city. However [Gregoir et al. \(2012\)](#) and [Banzhaf and Farooque \(2013\)](#) show that disparities of housing rates of return occur inside the urban area. These studies seem to contradict the effectiveness of non-arbitrage conditions, as they advocate that a disequilibrium exists at a local level. In a similar fashion [Glaeser and Gyourko \(2007\)](#) explain that it is difficult to demonstrate empirically that the non-arbitrage conditions are binding. Indeed, when they try to simulate a price using the non-arbitrage condition for renting and owning and compare it to a simulated price obtained with the financial non-arbitrage condition, they find a 40% difference between the two prices. They conclude therefore that this gap between the two simulated prices is the result of omitted variables that play a crucial role in the user-costs of homeowners and renters. In this chapter, we endeavor to explain the large disparities of rent-to-price ratios existing inside the urban area.

To that aim, we develop a theoretical framework in which we compare the user costs of renters and that of homeowners. In this model, we are able to define how the rent-to-price ratio is determined and why it is possible to observe different levels of rent-to-price ratio across locations inside the urban area. Then we implement an empirical analysis to test whether factors developed in the literature are really influencing the rent-to-price ratios at the local level. To perform such an empirical analysis we proceed following a two-step procedure. First of all, we use the hedonic method to evaluate the hedonic prices on both submarkets. With those estimates we simulate the missing rent or price for each observation in our database in order to obtain non quality biased rent-to-price ratios. Secondly, we regress these rent-to-price ratios on several factors as suggested by our theoretical framework.

[Narwold and Sonstelie \(1994\)](#) and [Diaz and Luengo Prado \(2008\)](#) show that the imputed rent of homeowners is not taxed as opposed to the rent paid by renters that is incorporated in the taxable income of the landlord. In addition, they explain that the credit constraint is a variable that plays a role in the decision to be a renter or a homeowner. Agents are credit-constrained because they must pay the bank a down-payment beforehand. This amount of wealth that agents must accumulate is a

positive opportunity cost that influences their decision to buy or rent. [Gregoir et al. \(2012\)](#) stress that the vacancy risk faced by landlords will also play a role in the rent-to-price ratio. When it takes longer for a landlord to find a renter, she faces a high opportunity cost. We include these three factors in the analysis because they are spatially heterogeneous inside the urban area. The spatial heterogeneity of these factors is what drive rent-to-price ratios to be different inside the agglomeration. Our empirical results show first that there exists a disparity of rent-to-price ratios inside the city of Lyon. Moreover, our results show that the vacancy risk, the credit constraint and the non taxation of imputed rents play a role in the rent-to-price ratio heterogeneity, even when we control for location characteristics.

The chapter is structured in seven sections. Section 1 introduces our chapter. Section 2 provides a summary of the literature related to our topic. In section 3, we develop a model in which we compare the costs for homeowners and landlords in order to compute the rent-to-price ratio. In section 4, we present the data. Section 5 presents the empirical strategy, regarding both the hedonic regressions and the regression of factors of disparities. In section 6, we discuss the results and section 7 concludes.

## 2 Related literature

### 2.1 User costs and rent-to-price ratios

When an agent wants to obtain shelter services, he must either rent or buy a dwelling. The cost per period for the agent when he decides to rent his dwelling is often in the literature considered as simply equal to the rent itself. However the situation is not as straight forward when the agent wants to buy his dwelling. In a two-periods setting, the user cost for homeowners include the running costs minus the expected plus-value ([Glaeser and Gyourko, 2007](#)). Furthermore, the user cost formula should also take into account the fact that the capital gains are included in taxable income, which is taxed at rate  $\tau^y$ . In addition, the property taxation rate  $\tau^p$  and the interest rate  $r$  will also play a role in the user cost level. The user cost in a two-periods setting is:

$$User\ cost\ of\ owning = (1 - \tau)(r + \tau^p)P_t - [P_{t+1} - P_t] \quad (1)$$

The work of [Diaz and Luengo Prado \(2008\)](#) sheds new light on the user cost formula. They rewrite the budget constraint in order to add new variables. In addition to the previous variables, the authors also take into account the fact that agents are credit constrained and that owners are subject to several transaction costs. These additions lead to new conclusions regarding the user cost formula.

First and foremost, the study notes that when agents are not credit constrained, it is always better for them to be homeowners. To understand this result, one must first consider the position of an investor. An investor will determine the price of the housing services he offers in order to cover the running cost of this rented dwelling. And the rent he will perceive will be subject to income taxes. This is a key difference between a homeowner and an investor. The homeowner will enjoy housing services but he will not pay the corresponding tax on the rent. Therefore, the cost a homeowner faces is lower than the cost born by an investor as long as the rental income of the owner is taxed. Consequently, if one disregards the credit constraint, it is always more advantageous to be a homeowner.

To reintroduce the renting/owning arbitrage, [Diaz and Luengo Prado \(2010\)](#) note that agents are credit constrained. Indeed, in order to become homeowners, agents must face a positive opportunity cost. This opportunity cost is the amount of wealth agents must gather in order to borrow. It depends

on the agents aversion to save. In this regard, [Diaz and Luengo Prado \(2008\)](#) note that when the credit constraint is added in the user cost formula, the decision to buy a dwelling is function of the agents capacity to accumulate the down-payment needed to buy a house. The credit constraint variable appears therefore to play a key role in the decision to buy or rent.

## 2.2 Local variations

The rent-to-price ratio has been extensively analysed at a macroeconomic scale. For example, [Himmelberg et al. \(2005\)](#) use aggregated values for rents and prices to compute rent-to-price ratios. A similar method is also applied in [Davis et al. \(2008\)](#) and [Gallin \(2008\)](#). Nevertheless, if this method is useful when one considers long time series variations, it has two drawbacks. The first one is the issue of quality bias. Indeed, it is not clear if these aggregated rents and prices concern similar dwellings or not. When this is not the case, disparities of rent-to-price ratios can be the result of differences in quality. To deal with the quality bias, it is possible to compute the rent-to-price ratio at the dwelling level. In order to do so, [Gregoir et al. \(2012\)](#) and [Hill and Syed \(2016\)](#) propose to predict the rent for a sold house or the price for a rented dwelling through hedonic regressions. This strategy allows the analyst to take into account the spatial heterogeneity of the characteristics of dwellings, which is especially important in locations where the characteristics of both rented and sold dwellings are largely different. [Hill and Syed \(2016\)](#) show that if the quality of the dwelling is kept constant, the rent-to-price ratio decreases by 18% in Sidney from 2001 to 2009 compared to an uncorrected ratio. Furthermore, they also noted that this difference is not stable over time. In 2009, the difference between quality-adjusted and not quality-adjusted rent-to-price ratios was zero. The second drawback is that empirical analysis tends to show that the rent-to-price ratio varies within spatial areas for which aggregated values are computed. Therefore, if the aim of the analysis is to point out that there exist arbitrage opportunities, it is not possible to tell in which parts of the agglomeration this occurs.

## 3 Theoretical framework

In this section we develop a simple theoretical framework to guide our empirical analysis. In a partial equilibrium model, describing the differences between agents on the market allows us to understand what kind of arbitrage they face. The housing market is subject to the three non-arbitrage conditions above described. Using these non-arbitrage conditions enables us to obtain conditions under which rent-to-price ratios are equal inside an agglomeration area.

### 3.1 Investor's viewpoint

The first arbitrage we will consider is the one that landlords face. Landlords seek to rent their house and obtain the highest profitability. One way to assess this profitability is to use the rent-to-price ratio, which is similar to the cap rate used in finance to compare the net operating income produced by an asset to the capital cost of that asset. Denoting the price  $P_{i,j,t}$  and the rent  $R_{i,j,t}$  for an asset  $i$  at date  $t$  in area  $j$  of the agglomeration, we can express the rent-to-price ratio simply as:  $\Phi_{i,j,t} \equiv R_{i,j,t}/P_{i,j,t}$ . However, this measure of profitability considers the profitability of an asset to be solely the result of an increase in the rent it generates at a fixed price. Taking into account the possibility of an increase in the selling price of the asset in the future, [Plazzi et al. \(2010\)](#) define the profitability of the housing

sector as:

$$1 + \mathcal{R}_{i,j,t+1} \equiv \frac{P_{i,j,t+1} + R_{i,j,t+1}}{P_{i,j,t}} \quad (2)$$

This more general formula is a powerful tool to analyse the housing market profitability because it states that the total profitability of an asset is the result of both capital gains and rental returns. This is an interesting feature, especially when one considers the financial non-arbitrage condition. Landlords face a choice: buying real estate or a standard financial asset. As they have the choice between two substitutes, in a market equilibrium they must earn equal risk-adjusted returns by investing in the housing market or in any other asset. If we express the price of a financial asset  $A$  and the cash flow it generates  $C$ , we can write the financial non-arbitrage condition as:

$$\frac{P_{i,j,t+1} + R_{i,j,t+1}}{P_{i,j,t}} = \frac{A_{t+1} + C_{t+1}}{A_t} \quad (3)$$

The financial non-arbitrage condition tells us that the profitability between the financial market and the housing market should be equal. Such a non-arbitrage condition implies that profitability should be equal between different houses  $i$  on the market. If the profitability of all houses is identical, it is nevertheless not a sufficient condition to claim that the rent-to-price ratios are equal as well. Indeed, profitability is equal to the sum of capital gains  $P_{i,j,t+1}/P_{i,j,t}$  and rental returns  $R_{i,j,t+1}/P_{i,j,t}$ . Inside an urban area one can witness neighbourhoods where the profitability of the housing market is high because capital gains are high and neighbourhoods where the profitability is high because the rental returns are high. The discrepancy here is apparent. Indeed, although the profitability of the housing market in these two neighbourhoods is equal, the rent-to-price ratio is not.

To further understand what induces a heterogeneity of rent-to-price ratios in an agglomeration, we adopt a modeling strategy similar to Glaeser and Gyourko (2007). First of all, we compute the market rent of a dwelling in a two-period model. If we assume that there are no profits at equilibrium, then the rent a landlord receives equals the running costs. The cost for a landlord  $C_{i,j,t}^r$  is:

$$C_{i,j,t}^r = (\tau_{j,t}^p + \delta_{i,j,t}^r + r_t)P_{i,j,t} - E[P_{i,j,t+1} - P_{i,j,t}] + \tau^y R_{i,j,t} - Z a_{i,j,t} P_{i,j,t} \quad (4)$$

The costs borne by landlords increase with the property tax rates  $\tau^p$  in the municipality  $j$ , the maintenance costs  $\delta$  and the interest rate  $r$ . On the contrary, the cost is lower when the expected capital gain  $E[P_{t+1} - P_t] \equiv \Delta_{i,j,t} P_{i,j,t}$  increases.  $R_{i,j,t}$  stands for the rent and  $\tau^y$  for the marginal income tax rate of the landlord; therefore  $\tau^y R_{i,j,t}$  is the amount of tax on rental income paid by the landlord.  $Z$  is a variable that takes value 1 if the dwelling is eligible to a buy-to-let tax advantage.<sup>1</sup> If the dwelling indeed meets the criteria for tax reduction, the landlord subtracts from his taxable income a share  $a$  of the dwelling price over the renting period.

Real estate assets are exposed to two types of risks, the liquidity risk and the vacancy risk. The liquidity risk refers to the situation when it might be difficult for a seller to find a buyer. The owner may suffer transaction costs of different types, either an opportunity cost corresponding to the time it takes

<sup>1</sup>In the French current setting, the criteria are that the dwelling is either new, or bought new. The dwelling must also be located inside a A, A bis, or B1 zone and must be rented within a period of 2 years after it is built. Furthermore, the dwelling's rent must not exceed a certain level and finally the renter income must not exceed a ceiling. The thresholds for renter income and rent per square meter are determined according to the zone by the French ministry of housing. The better the grade, the less restrictive are the thresholds for income and rents.

to sell his dwelling or to the agency fees he pays in order to reduce the time needed to sell. Nevertheless, we have no reason to believe that the liquidity risk affects differently landlords and homeowners. On the contrary, the vacancy risk affects landlords. Indeed, as we explained earlier, the amount of rents a landlord receives influences the profitability of the housing asset he owns. Between the moment a renter leaves and another renter moves in, there might be a period of time when the landlord does not receive any rent. In our model, landlords face a vacancy risk that is dwelling specific. We note  $v_{j,t}(R_{i,j,t})$  the probability for the dwelling to be vacant during period  $t$  to  $t + 1$ . This probability is what the landlord expects given the state of the housing market. In a perfect competition setting, the expected rent is equal to the landlord's production cost, hence:  $(1 - v_{j,t}(R_{i,j,t}))R_{i,j,t} = C_{i,j,t}^r$ . Finally, the renter user cost is equal to the rent plus the municipal housing tax, which is proportional to the dwelling price:

$$UC_{i,j,t}^r = \frac{C_{i,j,t}^r}{1 - v_{j,t}(R_{i,j,t})} + \tau_{j,t}^h P_{i,j,t} \quad (5)$$

### 3.2 Homeowner's viewpoint

The second non-arbitrage condition considers households who want to obtain housing services (Poterba, 1984; Henderson and Ioannides, 1983). The homeowners and the renters seek to obtain shelter services at the lowest possible user cost which is then equalized across the two tenures. If the user cost of homeowners was lower than the user cost of renters, there would be no renters at all.

The user cost of homeowners  $UC_{i,j,t}^h$  is:

$$UC_{i,j,t}^h = [\tau_{j,t}^p + \delta_{i,j,t} + \gamma_{i,t}\theta + (1 - \tau_h^y)(1 - \theta)r + \tau_{j,t}^h]P_{i,j,t} - E[P_{i,j,t+1} - P_{i,j,t}] \quad (6)$$

with the same notations as before. The housing tax is directly included in the user cost, as according to the French fiscal code, the homeowner pays housing and property taxes.

Before agents are granted a loan, if they don't already own a dwelling, they must pay the bank a down-payment. This down-payment equates a fraction of the housing price. If  $\theta$  is the down-payment rate required by the bank,  $\theta P_{i,j,t}$  is the total amount of down-payment (Diaz and Luengo Prado, 2008). This amount represents an opportunity cost for agents who decide to become homeowners. Indeed, these agents must sacrifice a share of their consumption in order to accumulate a sufficient amount of savings to pay the down-payment and obtain the loan.  $\gamma_{i,t}$  is a parameter which stands for the idiosyncratic cost of sacrificing immediate consumption in order to save. We include the credit constraint in the user cost of homeowners because we assume that new homeowners were renters previously. On the contrary, we do not include it in the cost taken on by landlords because we assume that they are already homeowners, which allows them to use their own dwelling as a guarantee in order to obtain a loan. For this reason, homeowners pay less interests as they borrow less money than landlords ( $P_{i,j,t} < (1 - \theta)P_{i,j,t}$ ), but they face an opportunity cost  $\gamma_{i,t}\theta P_{i,j,t}$  as they must sacrifice consumption in order to save.

Moreover, the user cost of homeowners accounts for the fact that homeowners are able to deduce the interest fees of their loan from their income tax. Their net amount of interests is  $(1 - \tau_h^y)(1 - \theta)r$ .

What is also interesting is the absence of the term  $\tau^y R_{i,j,t}^h$  in the homeowner user cost. The fact that homeowners benefit from untaxed rents is developed by Narwold and Sonstelie (1994); Sinai and

Gyourko (2004); Diaz and Luengo Prado (2008); Poterba and Sinai (2008). Homeowners benefit from an untaxed rent because they are at the same time renters and landlords. They rent a housing unit from themselves without paying any rent. Therefore, they benefit from an untaxed rent  $\tau^y R_{i,j,t}^h$  that is positively correlated with their marginal income tax rate bracket and the rent they would pay on the rental market.

### 3.3 Household's spatial arbitrage

The last non-arbitrage condition is spatial and has been developed by Alonso (1964); Rosen (1979). In this case, renters are indifferent to the various locations inside the urban area providing a housing unit with given characteristics. This spatial non-arbitrage condition means that if one part of the municipality is particularly attractive, agents will want to move to that area leading to a rent increase. The increase of rents will continue until agents become indifferent to the location in the urban area. Increase in rents for a given dwelling should be the result of an increase in the level of amenities this dwelling offers. Accordingly, the spatial non-arbitrage condition is an equality of utility levels derived in any location  $j$ . We can therefore express any utility level inside the agglomeration as equal to a constant  $k$ .  $\mathcal{A}$  represents the vector of location-specific amenities and  $Y$  the wage of the agents. Any increase in the amenity level impacts indifferently the renter user cost and the homeowner user cost as long as the homeowner-renter non-arbitrage condition holds.

$$UC_{i,j,t}^r = \mathcal{U}(Y - R_i, \mathcal{A}_i) = k \quad (7)$$

The spatial non-arbitrage condition and the assumption that homeowners and renters should be indifferent have spatial implications when combined. Indeed, in equilibrium inside a housing market, agents are indifferent between owning and renting. It means that the user cost of being homeowner equals the user cost of being renter. However, the spatial non-arbitrage condition states that agents should also be indifferent between locations as any increase in amenities should be captured by an increase in rent. Therefore, it is possible to extend the conclusion of the two non-arbitrage conditions, as agents should be indifferent between renting in one location and being a homeowner in another location.

### 3.4 Determinants of rent-to-price ratios

In order to highlight factors influencing the rent-to-price ratios, we compare equations [5] and [6] like Glaeser and Gyourko (2007). This comparison amounts to examine the conditions under which the user costs computed using the landlord's viewpoint and the homeowner's viewpoint are equal.

Equality of the two users costs is written:

$$UC_{i,j,t}^r = \frac{C_{i,j,t}^r}{1 - v_{j,t}} + \tau_{j,t}^h P_{i,j,t} = UC_{i,j,t}^h \quad (8)$$

which is equivalent to:

$$\frac{(\tau_j^p + \delta + r - \Delta_{i,j,t})P_{i,j,t} - Z a_{i,j,t} P_{i,j,t} + \tau^y R_{i,j,t}}{1 - v_{j,t}(R_{i,j,t})} = [\tau_{j,t}^p + \delta + (1 - \tau_h^y)(1 - \theta)r + \gamma_{i,t}\theta]P_{i,j,t} \quad (9)$$

Note that expected capital gains are assumed to be proportional to initial housing price, so that  $E[P_{i,j,t+1} - P_{i,j,t}] \equiv \Delta_{i,j,t} P_{i,j,t}$ .

On both sides of equation [9] are factors common to landlords and homeowners: property taxes ( $\tau_{j,t}^p P_{i,j,t}$ ), maintenance costs ( $\delta P_{i,j,t}$ ) and expected capital gains ( $\Delta_{i,j,t} P_{i,j,t}$ ). The impact of mortgages interests are different for the two categories:  $r P_{i,j,t}$  for landlords, but only  $(1-\theta)r P_{i,j,t}$  for homeowners, who however incur the opportunity cost of saving for a down-payment ( $\gamma_{i,t}\theta$ ). Moreover, landlords face a vacancy risk, hence the denominator  $1 - v_{j,t}(R_{i,j,t})$  on the left hand side.

This equation also entails terms related to fiscal policies specific to the two categories of agents: deduction of interest fees from taxed income for homeowners (factor  $(1 - \tau_h^y)$ ) and buy-to-let aids if applicable ( $Z a_{i,j,t} P_{i,j,t}$ ) and taxes on rent revenues for landlords.

Based on this equality, it is possible to write the rent-to-price ratio as follows:

$$\frac{R_{i,j,t}}{P_{i,j,t}} = \frac{(1 - v_{j,t}(R_{i,j,t}))[\theta(\gamma - r) - (1 - \theta) \tau_r^y r] - v_{j,t}(R_{i,j,t})(\tau^p + \delta + r - \Delta_{i,j,t}) + Z_{i,j,t} a}{\tau_h^y} \quad (10)$$

A few comments are in order. Firstly, consider a null vacancy rate. In this case, the rent-to-price ratio equals  $\theta(\gamma - r) - (1 - \theta) \tau_r^y r + Z_{i,j,t} a$ . The first two terms in this expression relate to the advantage specific to homeownership, which depends on the opportunity cost of the downpayment compared to the interest rate, and on the impact of interest fees deductibility.

Secondly, the term  $v_{j,t}(R_{i,j,t})(\tau^p + \delta + r - \Delta_{i,j,t})$  refers to the fact that the factors common to landlords and homeowners impact landlords more because of the risk of vacancy. If an external shock raises the vacancy rate, this difference between homeowners and landlords increases and rents decrease with respect to prices. On the other hand, a higher vacancy rate decreases the impact of the net homeowners' advantage, the sign of which is not determined.

Finally, a more generous buy-to-let aid (with a higher  $a$  or more housing units eligible) increases the rent-to-price ratio. In this case, landlords are able to offer dwellings for a lower rent, which in turn implies that agents are more likely to choose to become renters rather than to become homeowners. This decrease in the demand for home-owning compared to the increase of the demand for rental dwellings would induce an increase of the rent-to-price ratio.

## 4 Data

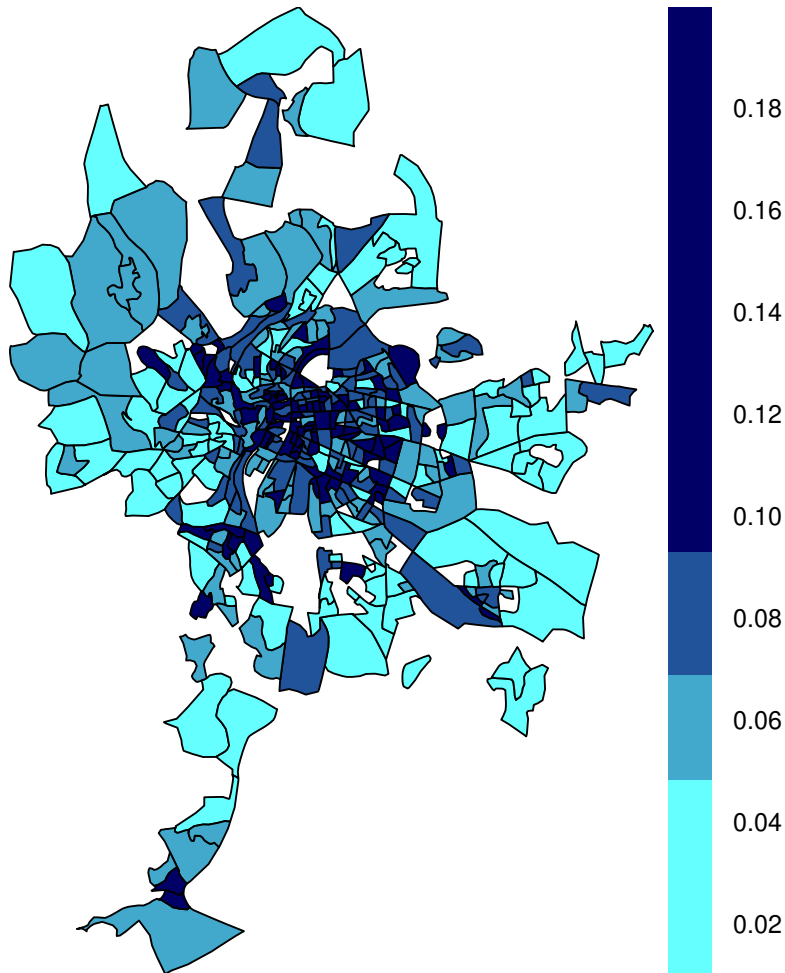
### 4.1 Context

Grand Lyon is a metropolitan area with 59 municipalities representing more than 1.300.000 inhabitants overall. Among these municipalities, Lyon is the most populated with approximately 500.000 inhabitants. The entire urban area of Lyon is in France second only to Paris when population is concerned. In addition, even if Lyon is considered administratively as a single municipality, it is divided in 9 different districts. Therefore, each time we mention the municipality level, we refer to the 58 municipalities of Grand Lyon plus the 9 districts of Lyon itself. To accommodate such a population, more than 650.000 dwellings exist inside the metropolitan area. During the period from 2001 to 2013, the pace of construction was steady with approximately 5800 new dwellings built each year. Among these, more than 80% are apartments and the rest is composed of houses. Furthermore, according to the *Direction Générale des Finances Publiques*, 47% of the households own their dwelling, 30% are renters in the private sector, and 23% renters in the public sector. Figure 1 plots the share of renters at

the neighborhood level.<sup>2</sup> Renters are more represented in central neighborhoods than on the periphery.

Figure 2 plots the average number of rooms of apartments. Inside the Grand Lyon, the distribution of apartments by size is not homogeneous. The 25% smallest apartments are located in the center of the agglomeration, which is a common feature in developed countries. However, the largest apartments are not located in the outer rim of the agglomeration as clearly as the smallest apartments are located in the city center. The 25% largest apartments are located mostly in the municipalities around Lyon and in the fifth district.

Figure 1: Percentage of renters per IRIS inside the metropolitan area in 2012



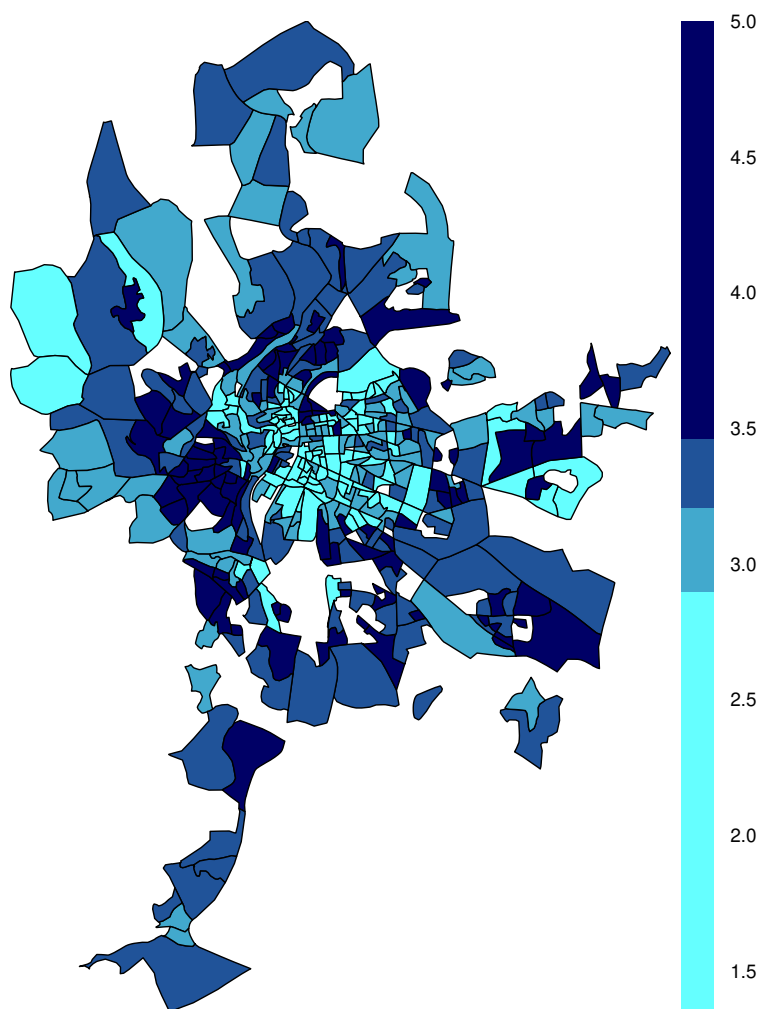
The oldest buildings are mostly located in the city center. Once again, Lyon is not a unusual case in that regard as in most French cities the city center is usually where buildings are the oldest. The apartments constructed between 1946 and 1990 are constructed mostly around the municipality of

<sup>2</sup>The finest spatial unit in the French Census is the IRIS ("*Ilots Regroupés pour l'Information Statistique*"). Each IRIS includes roughly two thousands inhabitants. In small municipalities, the IRIS level and the municipal level overlap. There are 512 IRIS in the study area. In the following, we will refer to neighborhoods.



Lyon. During that span the agglomeration grew steadily and more and more new apartments were built around the city center. The newest apartments in Lyon are located in the outer rim, but are also located in the eastern part of the Rhone. There are indeed a high number of buildings built during that period in the third, seventh and eighth districts of Lyon. In addition, Villeurbanne is also characterised by a high number of new buildings.

Figure 2: Average number of rooms per apartment in 2012 at the IRIS level



## 4.2 Database for prices

The database on housing prices, called PERVAL, is constructed by the French chamber of notaries. In this database, most of the sales that require an official registration by a notary are recorded. For each sale, a significant amount of information is recorded regarding the characteristics of the dwelling. Each sale is also geographically located, at the IRIS level.

In our analysis, we focus on housing and therefore concentrate only on house and apartment sales.

There are 12,262 sales recorded in the Lyon agglomeration during year 2014. Descriptive statistics are shown in Table [1] and in Table [2].

Table 1: PERVAL database - Descriptive statistics of quantitative variables

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	# valid obs.
Price (x1,000 euros)	14	126.5	175.8	214.6	257	3,000	12,602
Floor area (m <sup>2</sup> )	17	50	69	72	87	220	12,602
# rooms	1	2	3	3.252	4	22	12,370
# parking spaces	0	0	1	0.656	1	5	10,199
# bathrooms	0	1	1	1.117	1	7	12,052
Floor level	-2	1	2	2.683	4	26	10,410

Table 2: PERVAL database - Descriptive statistics of qualitative variables

EU Label	A	B	C	D	E	F	G	# valid obs.
# observations	39	136	918	1980	1221	342	146	4,782
Construction period	Before 1914	1914-1947	1948-1969	1970-1991	1992-2000	2000-2014		
# observations	326	1028	2216	2450	877	3145		10,042

For the price regression, we only consider apartments in the estimation sample. In addition, incomplete observations are also excluded from the sample. For the number of bathrooms and of parking places, a missing value dummy is created, so as to keep enough observations in the sample. The same is done for the energy performance certificate.<sup>3</sup> This leaves us with 8,705 observations.

### 4.3 Database for rents

The database on rents is gathered by a local public institution called OLL.<sup>5</sup> This observatory gathers data about rents from private real estate agents or from individual landlords. The database of the observatory of the Grand Lyon for year 2014 is composed of 11,868 rental units. Furthermore, rented dwellings are geographically located at the neighborhood level. The month the rental contract was signed is also included in the database. We also use this variable in our regression. Descriptive statistics are displayed in Table [3] and in Table [4].

Note that the recorded rents concern rental contracts signed during 2014 and the rental contracts still valid in 2014. As for transactions, only those that occurred in 2014 are in our estimation sample. Thus should be taken into account the fact that rents are likely to be more rigid than transactions when we will estimate the rent-to-price ratio.

### 4.4 Databases for explaining variables

Covariates used in the estimations are taken from different databases gathered by the INSEE.<sup>6</sup> Some information comes from the 2012 population Census, which is recorded at the municipal or neighborhood level. The variables taken from the Census are the vacancy rate, the percentage of families,

<sup>3</sup>In France, it is now compulsory to estimate the energetic performance for most dwellings before they are for sale. This diagnostic, called DPE<sup>4</sup>, aims to evaluate the amount of energy that is required to achieve a given national level of comfort. The results are expressed by grades ranging from A to G, the best grade being A and the lowest G.

<sup>5</sup>"*Observatoire local des loyers*" which can be translated as "local observatory of rents".

<sup>6</sup>"*Institut national de la statistique et des études économiques*", the National Institute of Statistics and Economic Studies.

Table 3: OLL database: Descriptive statistics of quantitative variables for rented housing units

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	# valid obs.
<b>Monthly rent</b>	96	490	603	661	753	5678	13,535
<b>Floor area</b>	9	43	57	61.73	74	361	13,535
<b># rooms</b>	1	2	2	2.55	3	9	13,535
<b># bathrooms</b>	1.00	1	1	1.05	1	3	1,854
<b># toilets</b>	1	1	1	1.05	1	2	1,854
<b>Floor level</b>	0	1	2	2.57	4	19	11,185

Table 4: OLL database: Descriptive statistics of qualitative variables for rented housing units

EU Label	A	B	C	D	E	F	G	# valid obs.
# observations	48	73	213	359	278	135	56	1,180
<b>Construction period</b>	Before 1919	19 to 45	46 to 70	71 to 90	91 to 05	05 to 14		
# observations	4,583	1,348	2,574	1,688	1,899	1,443		13,535

students and pensioners in the municipal population. We also use a measure of how long renters have lived in their dwelling, the percentage of capital income of renters and the third quartile of the median income of homeowners. These data come from another database called Filosofi. Finally, we use data on the fiscal grade attributed to each municipality concerning rental investors tax advantage eligibility. The grades go from C to A and only grades A to B2 can benefit from the buy-to-let tax advantage. All the variables and the geographical scale are displayed in Tables [5] and [6].

Table 5: List of variables from PERVAL and OLL for hedonic regressions

Variables	Description	Modality / unit
Number of rooms	Number of rooms per dwelling	1 to 22
Average living space	Total living space / number of rooms	$m^2$ per room
# parking places	Number of parking places	0(ref), 1+
# bathrooms	Number of bathrooms per dwelling	1(ref), 2+
Period of construction	Period the building was constructed	Before 1914, 1914-1947, 1948-1969 (ref), 1970-1991, 1992-2000, 2001-2014 for prices Before 1919, 1919-1945, 1946-1970 (ref), 1971-1990, 1991-2005, 2006-2014 for rents
Floor level	Floor on which the apartment is located	0, 1, 2 (ref), 3, 4, 5+
EU energy label	Grade	A, B, C, D (ref), E, F, G
Month of sale	Month the sale/rental contract was concluded	January (ref) to December

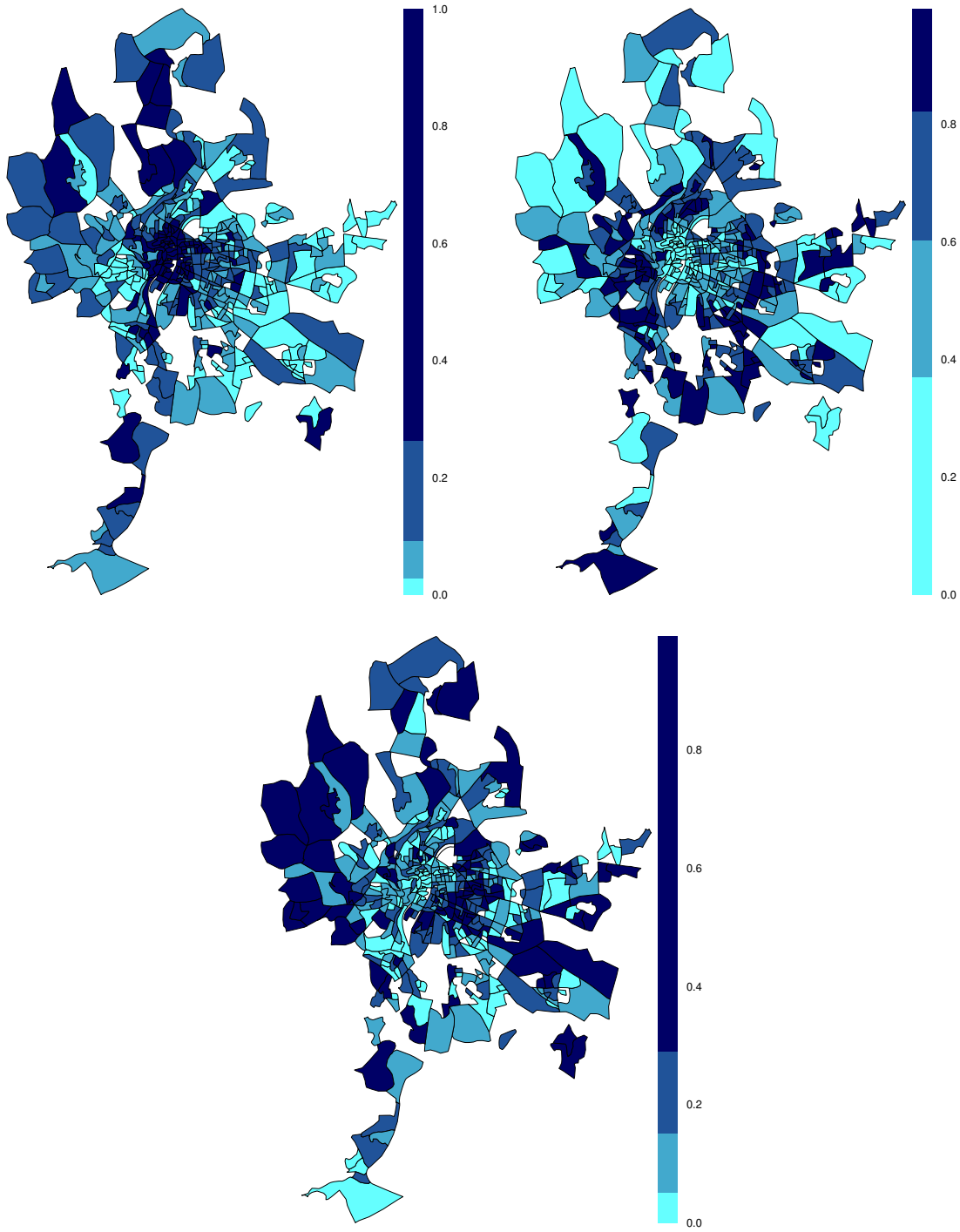


Figure 3: Share of dwellings according to construction period  
Top left: Before 1946 - Top right: 1946-1990 - Bottom: After 1990

Table 6: List of variables used and the level of recording for covariates in the main estimation

Variables	Geographic level	Year	Definition	Measure units	Source
Vacancy rate	Iris level	2012	Number of vacant dwellings over total number of dwellings	Percentage	Population census
Average capital income of renters	Municipal level	2012	Renters capital income divided over renters total income	Percentage	FILOSOFI
Third income quartile of homeowners	Municipal level	2012	The level of income that separate the 25% wealthiest from the 75% poorest	Absolute figure per year	FILOSOFI
Average duration of stay of renters	Iris level	2012	Total years the renters spent in their dweeling over number of dwellings	Years	Population census
% of families	Iris level	2012	Number of families over total number of households	Percentage	Population census
% of students	Iris level	2012	Number of students over total population	Percentage	Population census
% of retired	Iris level	2012	Number of pensioners over total population	Percentage	Population census
Buy-to-let aid zone	Municipal level	2014		Percentage	Ministry of Housing

## 5 Empirical model

The empirical analysis aims at assessing how strongly each disequilibrium factor affects the rent-to-price ratio. This analysis is conducted in two steps. In the first step, to insure that the disparities in rent-to-price ratios do not result from disparities of housing units on the two submarkets, we compute rent-to-price ratios at the dwelling level. To do so, we use the hedonic approach to estimate missing rents for sold housing units and missing prices for rental housing units. We then compute neighborhood level averages of these ratios. In the second step, we attempt to explain the spatial heterogeneity of rent-to-price. To do so, we regress these ratios on variables aimed at representing the factors that presented in the theoretical framework.

### 5.1 Hedonic equations

The hedonic price method is usually applied to goods that are defined by many different characteristics and is very commonly applied to the housing market. We use the hedonic price method to determine the shadow price for each characteristic of the dwellings on both sub-markets.

One important aspect of hedonic analyses is the functional form of the regression. The functional form choice depends on the objectives that one wants to achieve. [Cropper et al. \(1988\)](#) tried to assess what functional form performs the best. Their conclusion is that some functional forms perform better when the objective is to consistently estimate the coefficients and other functional forms when the goal is to accurately predict the price or the rent. As our aim is to recover missing prices or missing rents, we choose a functional form that yields the best prediction. According to [Sheppard \(1999\)](#), the functional form that achieves the best fit is a logarithmic form.

[Hill and Syed \(2016\)](#) argue that rent-to-price ratios computed at the dwelling level can be biased if there are omitted variable in the hedonic equations. To avoid such a bias, they match sold and rented dwellings using the postal address, so that the quality for observations in the rental hedonic equation and in the sale hedonic equation are strictly the same. Our data do not allow us to perform this sort of analysis. What's more, this method restricts the estimation sample and is likely to create a selection bias, as not all housing units are likely to be sold and rented in turn.

We want to include the same variables in the hedonic regressions of prices and rents. Indeed, if the variables are identical, we will be able to compare the two sets of estimated coefficients. In our model, we assume that the market is in equilibrium. However, if for some reason a large number of dwellings arrives on the market, it is possible that their characteristics will be more valuable to homeowners than to renters. Therefore, comparing the coefficients of the hedonic regression can help us understand how the rent-to-price ratio reacts in the short run. The standard variables in hedonic price regressions are the size of the dwelling, the number of rooms, the age of the building, the presence of a parking space, etc.

To estimate the hedonic equations of rents  $R$  and prices  $P$  of dwelling  $i$ , we include a set of dwelling characteristics  $X$  and a specific effect  $\omega_j$  or  $\gamma_j$  for each IRIS  $j$ . The hedonic formula for prices  $P$  is therefore :

$$\log(P_i) = \alpha_p + \beta_p X_{i,j} + \omega_j + \epsilon_{i,j} \quad (11)$$

The hedonic price formula for rents  $R$  is :

$$\log(R_i) = \alpha_r + \beta_r X_{i,j} + \gamma_j + v_{i,j} \quad (12)$$

with  $\epsilon_{i,j} \sim \mathcal{N}(0, \sigma_p^2)$  and  $v_{i,j} \sim \mathcal{N}(0, \sigma_r^2)$ .  $\sigma_p^2$  and  $\sigma_r^2$  are unbiased estimators of the log-linear regression model error for prices and rents.

## 5.2 Prices and rents simulation

The hedonic coefficients obtained from the above equations enable us to simulate pairs of prices and rents. In a similar fashion as [Gregoir et al. \(2012\)](#), we consider each housing unit in both of our databases and we apply the estimated coefficients to simulate the missing rent or price. We choose to use only the significant coefficients in the simulation process. This method of constructing the rent-to-price ratio is appealing as it enables us to compute the rent-to-price ratio for each dwelling, therefore at constant quality. The formula used to simulate the missing price is:

$$P_i = e^{\alpha_p + \widehat{\beta}_p X_{i,j} + \widehat{\omega}_j} \times e(0.5\sigma_p^2) \quad (13)$$

The formula used to simulate the missing rent is:

$$R_i = e^{\alpha_r + \widehat{\beta}_r X_{i,j} + \widehat{\gamma}_j} \times e(0.5\sigma_r^2) \quad (14)$$

Using this simulation method, we are able to compute a rent-to-price ratio for each dwelling of the agglomeration. They are then averaged at the neighborhood level. The neighborhood averaged rent-to-price ratios are mapped in [Figure \[4\]](#).

Note that the ratios we obtain when we simulate the rents and when we simulate the prices are likely to be different, as they are based on two different subsamples. Obtaining equal rent-to-price ratios when prices and rents are simulated would require that the two samples are identical and that the estimated coefficients are similar, two very unlikely hypotheses. Descriptive statistics for the two samples showing the differences in characteristics between rented units and sold units are displayed in [Tables \[1\] and \[2\]](#) and [Tables \[3\] and \[4\]](#).<sup>7</sup> The average rent-to-price ratios obtained from the rent simulation are displayed in [Appendix \[C\]](#) and those from the price simulation in [Appendix \[D\]](#).

## 5.3 Rent-to-price ratio equation

In a second step, we test which variables explain the spatial heterogeneity in rent-to-price ratios. To do so, we regress the simulated rent-to-price ratios on a set of variables as suggested by the theoretical framework.

To test whether the vacancy rate impacts rent-to-price ratios, we use the share of vacant dwellings in the neighborhood. The proportion of vacant dwellings includes indiscriminately dwellings that were previously rented or owner-occupied.

To account for the impact of credit constraints, we use a proxy capturing how difficult it is for agents to obtain a loan. It is not possible to observe directly the individual opportunity cost to save, and we rely on a proxy at the aggregate level. We use the share of renters' income that comes from capital revenues. This variable is measured in 2012 at the municipality level. If agents earn more income from their capital, it means that they possess more capital and are thus likely to have a lower opportunity cost of downpayment accumulation.

The theoretical framework suggests an impact of the untaxed imputed rent of homeowners on the rent-to-price ratio. As the income taxation is progressive, this effect is supposed to be stronger for

<sup>7</sup>See also [Table \[8\]](#) and [Table \[7\]](#) for estimated coefficients on the two subsamples

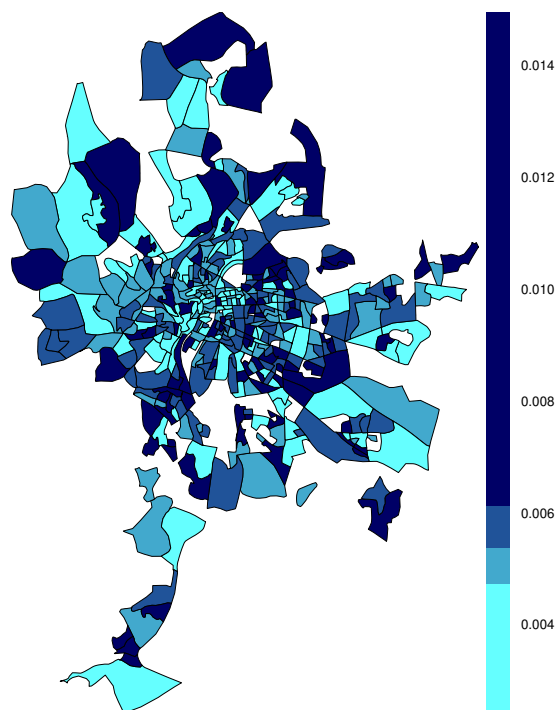


Figure 4: Mean average of rent-to-price ratios at the IRIS level inside Grand Lyon in 2014

individuals who earn a higher income (Narwold and Sonstelie, 1994). We do not have the individual income of homeowners, but we use the third quartile of homeowners' income measured at the municipal level. The aim is to measure the income of those that benefit the most from this tax advantage, namely here the 25 % wealthiest homeowners.<sup>8</sup>

The rental investment eligibility zone in which the dwelling is located is also included in the regression. When the building is in a grade A zone, the dummy takes value 1. On the contrary when the building is in a B1 zone, where the tax advantages are lower, the dummy takes value 0.

Finally, we must account for the fact that rents in the database are measured on a stock, as they concern rents paid during year 2014, and not only new rental contracts for that year. Therefore, we include the average duration of stay of renters as a control. The idea is that if rents are more rigid than prices, the average renters length of stay should significantly impact the rent-to-price ratio with a negative coefficient. We also include a few more control variables, aimed at taking into account differences in demand for rental housing and for owner-occupied housing for some specific dwelling characteristics. First, as will be shown in the following, the estimated coefficients for dwelling of 3 to 4 rooms are higher for sold dwellings than for rented dwellings. This can be interpreted as a higher demand for owner-occupied large housing units, than for their rented counterparts. This demand is triggered by families with children. The share of families with children in total households is therefore included as a control. Second, the impact of the month on which the dwelling is rented is very significant

<sup>8</sup>The FILOSOFI database includes information at the municipal level for the first and third quartiles of income, and for median income. We also used median income in the estimation. The magnitude of the estimated coefficient is then lower than with third quartile; the estimated coefficient remains however negative and significant.



in the rent hedonic estimation, while it is not in the price regression. In addition, estimated coefficients for 1 or 2 rooms dwellings are higher in the rent regression than in the price regression. This is likely to result from a higher demand for small housing units on the part of students. We therefore control for the percentage of students in the neighborhood population. Finally, we also include the percentage of pensioners in the regression. The underlying idea is similar to the one exposed for the student population.

## 6 Results

### 6.1 Descriptive statistics

The average selling price in the PERVAL database is 214,600 euros (Table 1). Computed at the municipal level, average selling prices vary from 1,716 euros per square meters in Givors to 5,067 in Saint-Didier-au-Mont-d'Or. The most expensive part of the metropolitan area is located at the West of the central city of Lyon (see map in Appendix [9]). Lower average selling prices are observed on the eastern part of the metropolitan area.

Descriptive statistics of the rental market show that the average rent in the agglomeration is 661 euros per month, with a maximum of 5,678 and a minimum of 96 (see Table 3). The average rental price per square meter per month is 10.57. The spatial distribution of rents is not as clear as that of prices. Most of the highest rents are located in the city center (see map in Appendix [10]). Some neighborhoods in the north-west of the agglomeration are in the highest quartile, but there are also neighborhoods in the lowest rent quartile in that area.

A comparison of the two databases shows that the surface of rented dwellings is on average smaller than those of sold dwellings. Most of the large rental dwellings are located in the north-western part of the agglomeration. The smallest rental dwellings are located in the 7th and 8th district of Lyon, but also in the surrounding municipalities on the eastern side of Lyon, such as Villeurbanne or Bron.

The vacancy rate is measured for year 2012. It seems to follow a very clear spatial pattern. The neighborhoods where the vacancy is high are located in the city center of Lyon. As one goes further away from the center, the vacancy rate decreases.

The north-western part of the agglomeration of Lyon is where the wealthiest owners are located. In addition the owners in the 1<sup>st</sup>, 2<sup>nd</sup> and the 3<sup>rd</sup> districts are also among the wealthiest. On the contrary the south-east part of the agglomeration is characterized fewer wealthy owners.

In a similar fashion, the renters with a high proportion of their income stemming from capital are located in the the north-western part of the agglomeration. Once again the town center is also characterized by a large share of renters' income coming from capital. The south-east of the agglomeration is where the renters have the lowest share of income coming from capital.

### 6.2 Hedonic price and rent models

We now present the estimation results of the hedonic price model for sold dwellings. The model is estimated on a sample of 8,702 dwellings. Location specific effects for each IRIS are included in the estimation, therefore we have 473 neighborhood fixed effects. The model fit for price regression is of 0.72 which is reasonably high.

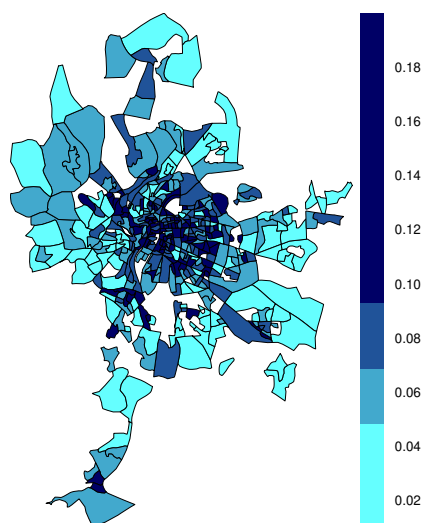


Figure 5: Mean average vacancy rate in 2012

The hedonic regression for rents uses the same variables on a sample of 9,992 dwellings. As for the price hedonic estimation, neighborhood fixed effects are included. 480 fixed effects are estimated. The difference in the number of neighborhoods in both regressions is due to a difference in the sample used for rents and prices. No rents or no price are recorded in some neighborhoods. In the rent regression we have a slightly better adjusted  $R^2$  of 0.76.

In both regressions for prices and rents, the estimated coefficients for the number of rooms are all significant and positive. The clearest difference appears when we consider dwellings of three or four rooms. Indeed, it is there that the spread between both sub-markets is the highest. Prices for apartments of three or four rooms are 33% and 54% higher than apartments of two rooms for sold units whereas they only increase by 26% and 47% for rented apartments. However, there are very few differences between both sub-markets. The average living space per room is also significant in both regressions and with the expected positive sign. Indeed, if the number of rooms is a very relevant determinant of price and rent, the room size is also expected to play a role in the price and rent determination. Interestingly, the average room size coefficient is significantly higher in the price regression than in the rent regression.

Before comparing hedonic prices for construction periods, it is worth noting that the construction periods in both regressions do not match exactly. The differences are however very slight and should not interfere with the comparison with maybe the exception of the last period of construction where there is a difference of five years. The construction period seems not to affect prices and rents in the same way. First of all, recent buildings tend to have higher prices and higher rents. However, the similarity stops here as the rest of the estimated coefficients are different. In the rent regression, an older building seems to be less expensive than a newer building as the estimated coefficients increase the more recent the building is. However this is not as clear in the price regression. The estimated coefficients are mostly not significant apart for the recent period of 2001 to 2014 and the period from 1914 to 1947. Only the coefficient for new buildings in the price regression is close to the coefficient in

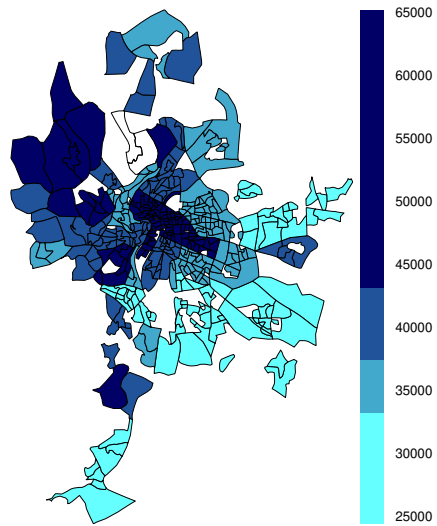


Figure 6: Third quartile of income by municipality in 2012

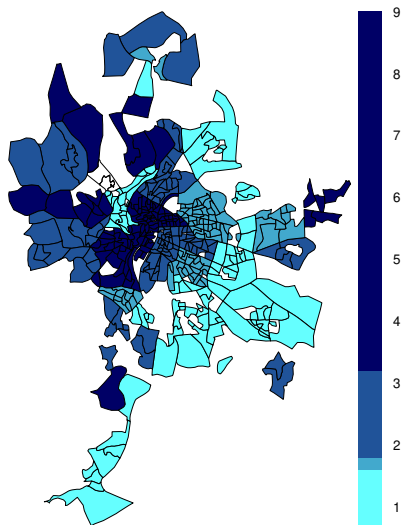


Figure 7: Share of renters' capital income by municipality in 2012

Table 7: Hedonic price regression for housing prices

	<i>Dependent variable: Log of prices</i>	
1 room	-0.434***	(0.011)
2 rooms	Ref.	
3 rooms	0.334***	(0.009)
4 rooms	0.541***	(0.014)
5 rooms	0.727***	(0.019)
6 rooms ou plus	0.963***	(0.026)
Average living space per room	0.024***	(0.003)
One or more parking place	0.169***	(0.008)
Number of parking not available	0.010	(0.017)
More than one bathroom	0.172***	(0.015)
Number of bathrooms not available	-0.117***	(0.019)
Constructed before 1914	0.014	(0.012)
Constructed from 1914 to 1947	0.064***	(0.014)
Constructed from 1948 to 1969	Ref.	
Constructed from 1970 to 1991	0.005	(0.011)
Constructed from 1992 to 2000	0.014	(0.013)
Constructed from 2001 to 2014	0.181***	(0.010)
Ground floor level	0.108	(0.104)
1 <sup>st</sup> floor	-0.025***	(0.008)
2 <sup>nd</sup> floor	Ref.	
3 <sup>rd</sup> floor	-0.003	(0.009)
4 <sup>th</sup> floor	0.018*	(0.010)
5 <sup>th</sup> floor or more	0.001	(0.011)
EU energy label A	0.079	(0.053)
EU energy label B	0.083***	(0.028)
EU energy label C	0.070***	(0.013)
EU energy label D	Ref.	
EU energy label E	-0.054***	(0.012)
EU energy label F	-0.069***	(0.020)
EU energy label G	-0.188***	(0.030)
EU energy label not available	-0.025***	(0.008)
January	Ref.	
February	0.018	(0.014)
March	0.003	(0.014)
April	0.005	(0.017)
May	0.017	(0.016)
June	0.006	(0.014)
July	0.018	(0.014)
August	0.001	(0.015)
September	0.027*	(0.015)
October	0.007	(0.015)
November	0.023	(0.017)
December	0.002	(0.017)
Number of Iris fixed effects	473	
Observations	8,702	
R <sup>2</sup>	0.740	
Adjusted R <sup>2</sup>	0.724	
Residual Std. Error	0.264 (df = 8192)	

Note:

\* p&lt;0.1; \*\* p&lt;0.05; \*\*\* p&lt;0.01

the rent regression. In both regressions, a building finished after 2006 is rented or sold 18% more than a building built before 1914. The buildings constructed between 1914 and 1947 are sold 6% more than buildings constructed before 1914. These are the only two significant periods of construction variable

Table 8: Hedonic rent regression for housing rents

	<i>Dependent variable: Log of rents</i>
1 room	-0.407*** (0.006)
2 rooms	Ref.
3 rooms	0.267*** (0.005)
4 rooms	0.473*** (0.006)
5 rooms	0.709*** (0.011)
6 or more rooms	0.972*** (0.019)
Average living space per room	0.018*** (0.0003)
One or more parking place	0.047*** (0.009)
Number of parking place not available	0.045*** (0.009)
More than one bathroom	0.011 (0.028)
Number of bathrooms not available	0.025** (0.010)
Construted before 1919	0.011* (0.006)
Construted from 1919 to 1945	0.001 (0.008)
Construted from 1946 to 1970	Ref.
Construted from 1971 to 1990	0.066*** (0.007)
Construted from 1991 to 2005	0.155*** (0.008)
Construted from 2006 to 2014	0.179*** (0.009)
Ground floor level	0.021*** (0.006)
1 <sup>st</sup> floor	-0.007 (0.005)
2 <sup>nd</sup> floor	Ref.
3 <sup>rd</sup> floor	0.003 (0.005)
4 <sup>th</sup> floor	0.007 (0.005)
5 <sup>th</sup> floor or more	-0.007 (0.006)
EU energy label A	-0.089** (0.038)
EU energy label B	-0.043 (0.033)
EU energy label C	0.008 (0.023)
EU energy label D	Ref.
EU energy label E	-0.006 (0.020)
EU energy label F	0.004 (0.025)
EU energy label G	0.011 (0.035)
EU energy label not available	0.074 (0.094)
January	Ref.
February	0.025*** (0.010)
March	0.028*** (0.010)
April	0.021** (0.009)
May	0.025*** (0.010)
June	0.038*** (0.009)
July	0.017** (0.008)
August	0.046*** (0.008)
September	0.036*** (0.008)
October	0.020** (0.008)
November	0.027*** (0.009)
December	0.032*** (0.009)
Number of Iris fixed effects	480
Observations	9,992
R <sup>2</sup>	0.779
Adjusted R <sup>2</sup>	0.768
Residual Std. Error	0.172 (df = 9541)

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

in the price regression. The fact that the new buildings are more expensive is not surprising. It is however less straightforward for the period ranging from 1914 to 1947. Most of the buildings from that

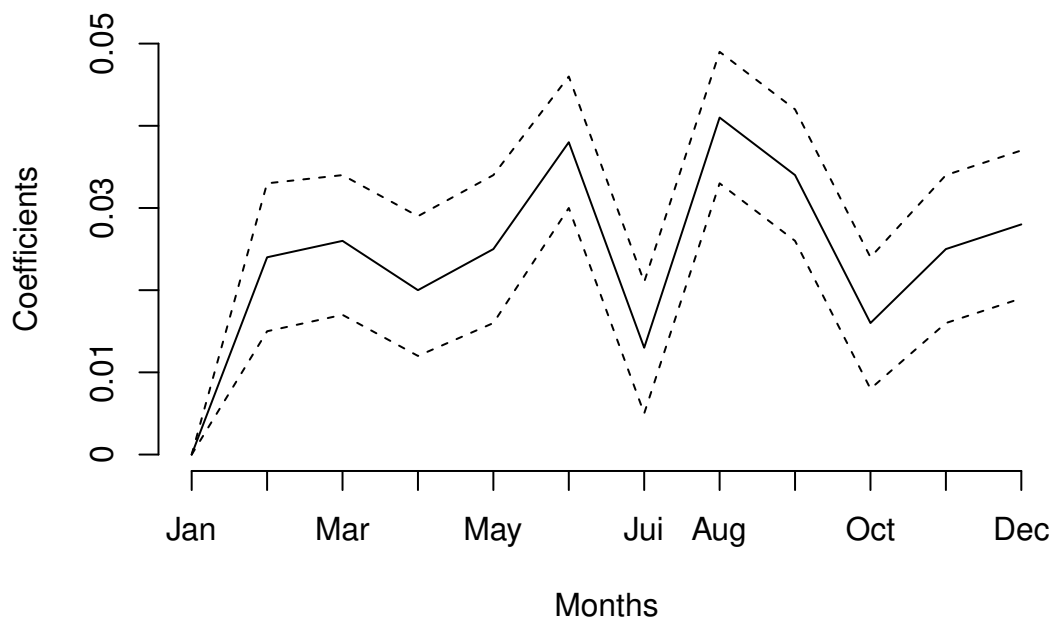


Figure 8: Estimated coefficients and confidence interval for rental contract month

period correspond to buildings that are located in the city center. These type of dwellings are very popular because of attributes not included in our hedonic regressions. Indeed, they usually possess popular aesthetically pleasing features that explain why they are more valued than otherwise similar dwellings (Ahlfeldt and Holman, 2016).

When it comes to the floor level, the ground floor level is slightly more expensive than the second floor in the rent regression, however the effect is fairly small. Estimated coefficients for the other floor levels are not statistically significant. For sold dwellings, the coefficient estimated for the ground floor level is not statistically different from the second floor, whereas the first and fourth floor are the only statistically significant coefficients. To measure more accurately the impact of the floor level on the prices or on the rents we would need information about elevators; unfortunately there is none included in our databases.

The estimated coefficients for the EU energy performance certificates are very significant in the price regression. Compared to the label D, the coefficients are all negative and significantly so for labels E, F and G. Additionally, the estimated coefficients also decrease as the label decreases. This is a reasonable result as those labels denote a dwelling that requires more energy. The results for energy labels C and B are positive which is also what was expected as dwellings with those grade consume less energy. The energy label A is not significant, which is not surprising as there are very few dwellings with such a good grade in our database of home sales. On the contrary in the rent regression those energy labels are not significant with the exception of the label A. However this result is at odds with

our expectations because the sign is negative which means that a dwelling with grade D cost 8% more to rent. Otherwise no other label is significant.

Finally the impact of the month on which sales or rents are made is also very different between the two sub-markets. Indeed, all coefficients are significant in the rent regression, whereas only one is in the price regression. Rents seem to be set specially higher in June, August and September. This time of year coincides with the start of the new student year and with many residential moves.

On the contrary, in the price regression only one estimated coefficient is significant, namely September. However the significancy level of this particular coefficient is fairly low. These results suggest that rents are subject to a seasonal effect whereas prices are not.

### 6.3 Main results

The results of the rent-to-price estimation are displayed in table [9]. The results of this second step show that the vacancy rate has a strong impact on rent-to-price ratios. The vacancy rate is significant in both specifications (without and with control variables) and bears a positive sign. Those results mean that the rent-to-price ratio increases when vacancy does. This results sets our work apart from [Gregoir et al. \(2012\)](#), who find that the rent-to-price ratios are lower when the vacancy is high. The first possibility to explain this discrepancy is a potential endogeneity of our measure of vacancy. However, our measure of the vacancy rate is lagged by two years, which lowers the endogeneity issue. Another possible explanation is that the state of the housing market in the two agglomerations studied is different.

The coefficient for the percentage of renters income that comes from capital is significant and negative: the higher the share of capital income, the lower rents relative to prices. We interpret this result as showing that a decrease in the credit constraint leads to a relative increase of prices compared to rents. With those results we are in line with what our model and [Diaz and Luengo Prado \(2008\)](#) predict.

The coefficient for the third quartile of owner's income is also negative and significant: the higher the share of high income households, the lower rents relative to prices. An interpretation of this result could be related to the fact that the propensity to own is the higher, the wealthier the households. In wealthy neighborhoods, prices increase therefore faster than rents and therefore the rent-to-price ratio decreases. This result is in line with what [Narwold and Sonstelie \(1994\)](#) found when they claimed that in a income tax system where the marginal tax level increase with income, the impact of untaxed imputed rent is higher for the wealthier homeowners.

The impact of the rental investment eligibility zone is not significant. This result seems to imply that the higher tax advantages that landlords in zone A benefit from compared to landlords in zone B1 do not explain variations of the rent-to-price ratio. According to this result, the potential impact of tax advantages on housing prices is compensated by a proportional increase in rents.

The variable included to take into account the fact that observed rents are more rigid than prices is not significant. This result suggests that, even if there are institutional mechanisms that restrict the rent increases, these restrictions do not explain why rent-to-price ratio are heterogeneous in space. In a second specification, we take into account the percentage of families, the percentage of students and the percentage of pensioners to check whether it changes our results. Including these control variables does not change any of the coefficients signs and all variables that were significant still are (see columns 3 and 4 in Table 9).

Table 9: Rent-to-price ratios estimation

	<i>Dependent variable: Ratio ×100000</i>			
	<i>Without control variables</i>		<i>With control variables</i>	
	<i>OLS</i>	<i>Municipaly clustered SEs</i>	<i>OLS</i>	<i>Municipaly clustered SEs</i>
	(1)	(2)	(3)	(4)
Vacancy rate	505.509** (204.714)	505.509* (270.170)	547.070** (218.662)	547.070* (298.350)
Average capital income of renters	-12.693 (8.193)	-12.693** (6.153)	-13.972* (8.254)	-13.972** (6.501)
Third income quartile of owners	-3.268** (1.591)	-3.268** (1.294)	-3.097* (1.596)	-3.097** (1.344)
Fiscal zone	-2.912 (15.045)	-2.912 (11.454)	-4.352 (18.447)	-4.352 (12.708)
Average duration of stay of renters	4.044 (5.104)	4.044 (6.754)	5.274 (5.604)	5.274 (7.876)
% of families			4.181 (79.608)	4.181 (86.092)
% of students			155.389 (116.434)	155.389 (111.974)
% of pensioner/retired			529.427 (626.864)	529.427 (539.999)
Constant	654.954*** (50.600)	654.954*** (51.792)	607.792*** (83.674)	607.792*** (103.044)
Observations	401		401	
R <sup>2</sup>	0.107		0.113	
Adjusted R <sup>2</sup>	0.096		0.095	
Residual Std. Error	126.932 (df = 395)		127.032 (df = 392)	
F Statistic	9.507*** (df = 5; 395)		6.230*** (df = 8; 392)	

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

## 7 Conclusion

In this chapter, we have shown that local rent-to-price ratios are heterogeneous inside the urban area. These heterogeneous rent-to-price ratios are computed through a simulation exercise. Indeed, for each sale and rents, we computed the according rent or price for the same dwelling. To simulate those prices and rents we performed a hedonic regression for both sub-markets. We then used the estimated coefficients to simulate either the price of a rented dwelling or the rent of a sold dwelling. This method allows us to compute individual rent-to-price ratios. In a first analysis, we are able to show that renters and owner-occupiers have different valuation for apartment characteristics.

We performed a regression to determine which factors impact neighborhood-averaged rent-to-price ratios inside the urban area. The results, even if they do not correct for potential endogeneity issues, are consistent with the theory. They are suggestive of an impact of local variations of vacancy rate, credit constraints of renters and untaxed imputed rent of homeowners on the rent-to-price ratio. In addition, once socio-economic variables such as the percentage of families, of students or of pensioners are controlled for, results do not change. This suggests that the differences in taxation on both sub-markets are explaining part of the heterogeneity in rent-to-price ratio in the urban area. Our results are in line with the previous literature on rent-to-price ratios and add to this previous literature several



factors that can explain local heterogeneity in rent-to-price ratios.

These results are interesting for public policy makers and also for investors as they show how both sub-markets are linked. The theoretical framework and our empirical results suggest that the different taxations on both sub-markets play a role on the rent-to-price setting. If policy makers want to alter the municipal mix between renters and homeowners, our results suggest that several channels are available. In Lyon, one the aim of policy makers is to supply affordable housing. Our results suggest that in areas where vacancy is high, the rent-to-price ratio is also high. If the public administration of the city is able to propose a mechanism to insure landlords against vacancy risk, our results suggest that the rent-to-price ratio should decrease. However, it is not possible to assess whether a change in the rent-to-price ratio comes from price increases or rent decreases. In that regard, these results are interesting because they show that a policy that aims to promote lower rents, could induce higher prices as well.

This analysis also highlights that aggregated rent-to-price ratios at the agglomeration level are less relevant than ratios computed locally, as they tend to yield less information about arbitrage opportunities, which is an information that investors seek. Moreover, it also indicates how rent-to-price ratios are likely to react when banks ask for higher down-payments or when the income of individuals rises.

One of the main drawback of our analysis is that we only have data on rents in 2014. Our database on rents exist only since 2014 and at the time this chapter is written, this is the only year available. Thus, in terms of future research, it would be interesting to use data on rents spanning on more than one year. With such a database, it could be possible to produce results that could be more precise and perhaps able to correct the endogeneity issue in rent-to-price regression.

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## A Map of mean prices

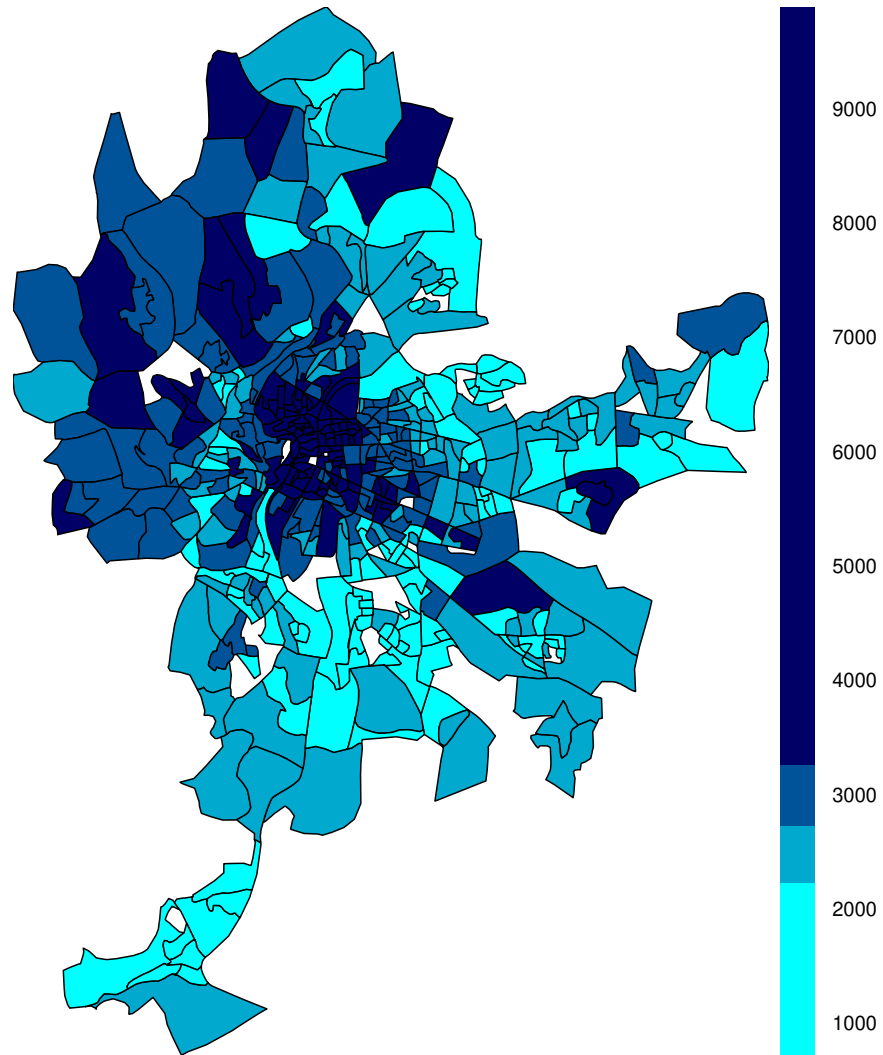


Figure 9: Mean average of the dwelling price per square meter at the IRIS scale inside the metropolitan area in 2014

## B Map of mean rents

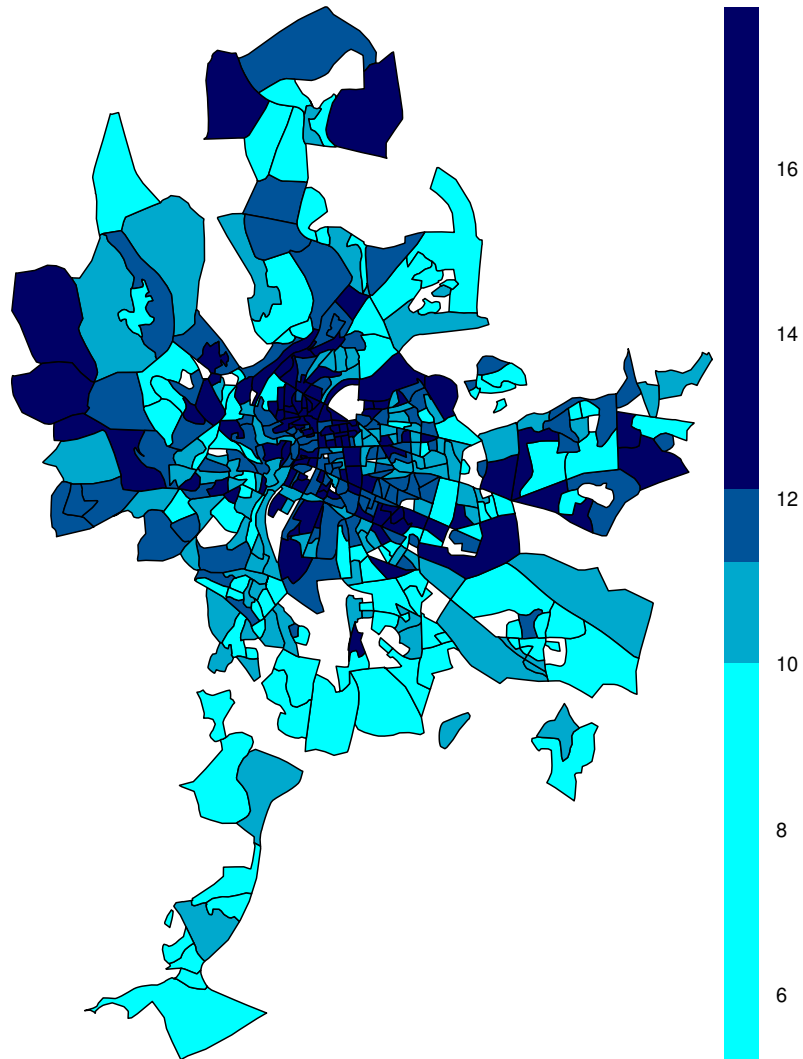


Figure 10: Mean average of the dwelling rents per square meters at the IRIS scale inside the metropolitan area in 2014

### C Map of mean rent-to-price ratios on transaction sample

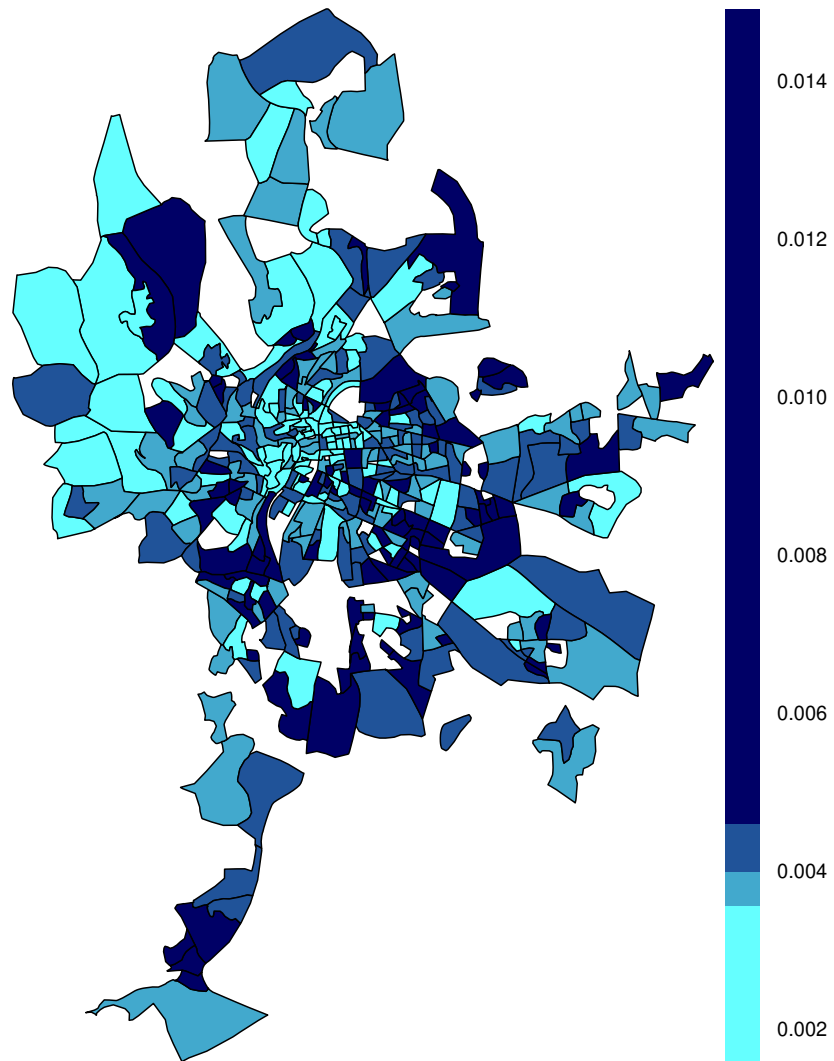


Figure 11: Mean average of the dwelling rent-to-price ratio with simulated rents at the IRIS level inside the metropolitan area in 2014

## D Map of mean rent-to-price ratios on rented housing sample

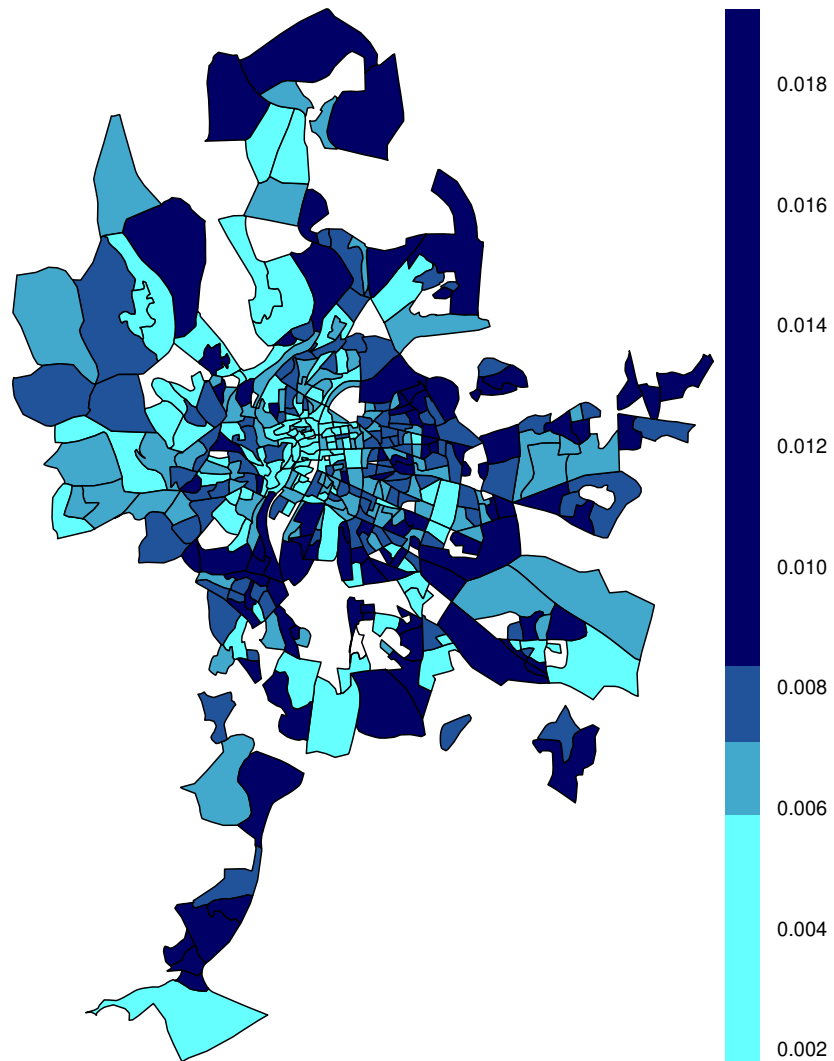


Figure 12: Mean average of the dwelling rent-to-price ratio with simulated prices at the IRIS level inside the metropolitan area in 2014

## Chapter 2 :

### Impact of publicly funded dwellings on private housing prices

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#### *Abstract*

This chapter evaluates the impact of the construction of social housing on the property price of the same municipality. The chapter presents two different methods, a difference-in-differences design and a regression discontinuity design to estimate the impact of subsidies directed towards construction of social housing. The results show that whether municipalities are large or small, social housing construction is associated with a decrease in private housing prices.

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## 1 Introduction

In many countries, the public sector produces dwellings with regulated rents. The aim of such policies is to ensure that the majority of the population has access to a home. But likewise other public policies, when an accommodation is built and managed by public authorities, is raised the question of the crowd-out effect. The crowd-out effect occurs when the state's action on an economic market drives out private actors in that economic sector. In this case, the crowd-out effect occurs when public authorities provide social housing and drive out private construction. Through literature, a number of empirical contributions using US data show that the crowd-out effect exists (Murray, 1983, 1999; Malpezzi and Vandell, 2002; Sinai and Waldfoegel, 2005; Eriksen and Rosenthal, 2010). More so, other studies show similar results throughout the world. Chen and Nong (2016) show that the crowd-out effect takes place in China, Lee (2007) in South Korea, Pinar and Demir (2016) in Turkey and Chapelle (2014) and Gobillon and Vignolles (2016) in France. However, if these studies show that the crowd-out effect does indeed exist, they differ when addressing the magnitude of the said effect. They explain these differences with the way the housing is established. First of all, economic theory highlights how the magnitude of the crowd-out effect varies according to the demand elasticity (Eriksen and Rosenthal, 2010). For this reason, it is conceivable that the crowd-out effect differs between cities, the types of dwellings and the targeted populations. Lee (2007) demonstrates that when the private housing market in a given city is saturated, then the crowd-out effect will be low or non-existent. Chen and Nong (2016) show that beyond a certain amount of social housing, the crowd-out effect is strong. Pinar and Demir (2016) reveal that the crowd-out effect is important when social housing is aimed at moderate-income households whereas it is close to non-existent when aimed at low-income dwellers. Moreover, Glaeser and Gyourko (2005) show that in US cities where the price for privately-owned housing drops below the construction costs, a situation that can happen to landlords driven out of the housing market by new social housing, the reaction on the price of accommodation is very strong. For this reason, an interesting question worth pursuing is (i) what is the impact in France of the construction of social housing on the prices of properties, (ii) and is this impact observable at different municipal scales ?

## 2 Related literature

When the State intervenes on the private housing market by providing publicly founded accommodations, it raises the question of the crowd-out effect. The crowd-out effect occurs when a public authority decides to produce additional amounts of a good already traded on the private market. As a consequence, the price as well as the amounts provided by private individuals will be disrupted by

this new public supply. [Eriksen and Rosenthal \(2010\)](#) present this mechanism in figure ???. In figure ???  $SH$  stand for social housing. In this case, the amount of public housing newly available increases the total amount of housing, thus moving the supply curve towards the right. However this increase in the amount of housing available is not without consequence on the price, as the amounts of dwellings is now higher. Price ( $P_0$ ) without any supply of social housing is higher than the price ( $P_1$ ). The total amount of dwellings will increase following the construction of additional social housing, but it will not increase as much as expected, as a fraction of the private suppliers will not be able to adjust to the new equilibrium price and will therefore be driven out of the market. The actual number of dwellings is  $H_2$  and not  $H_1$ . The quantity of housing supplied is higher after the state supplied social housing ( $H_1 > H_2 > H_0$ ). In this graphic representation, the amplitude, namely the amount of dwellings ousted, depends on the slope of the demand curve. In this “modeling” it is even possible for the housing demand to be only marginally reactive to an increase or decrease in prices, so that the crowd-out effect can become nonexistent. This means that the public policy does not crowd the landlords out of the housing market.

A number of contributions offer estimations on the crowd-out effect. [Sinai and Waldfogel \(2005\)](#) show that the LIHTC program in the us, did indeed cause a crowd-out effect. To carry out their estimation, they use data concerning 22,872 neighborhoods in 252 MSA on a period stemming from 1990 to 1996. In order to observe the crowd-out effect, they regress the total amount of housing against the amount of public funded housing. They use measures per capita to correct for the size effect bias. They also only focus on inhabited accommodations to avoid biases induced by measurement mistakes. Furthermore, they can also differentiate if an individual from the region inhabits the dwelling or if someone from another region inhabits it. They show that when four dwellings are subsidized, the total stock of dwellings increases by one extra dwelling. Likewise [Eriksen and Rosenthal \(2010\)](#) work on the LIHTC. To assess the magnitude of the crowd-out effect they use a database of 17,774 LIHTC projects on a period stemming from 1990 to 2000. They do not notice a crowd-out effect at the MSA scale, however they observe a crowding out effect at the county scale.

[Chen and Nong \(2016\)](#) try to assess the crowd-out effect on the Chinese territory. To do so, they use data from 29 Chinese provinces, from 1999 up to 2010. They are able to show that a crowd-out effect exists in China but that its amplitude is weak. Moreover, they seek to determine at which threshold the crowd-out effect starts to occur. Their results seem to indicate that only one of the three following conditions needs to be met for the crowd-out effect to occur. First of all, when there are more than 16% of social housing in the housing market, secondly when the prices of social housing amount to less than 58% of the prices of private housing, and finally when the construction markets share is lower than 5,5% in the local economy, then the crowd-out effect appears.

[Pinar and Demir \(2016\)](#) show that the crowd-effect also exists in Turkey. They focus their study

on trying to observe if the crowd-out effect exists when social housing targets mainly very low-income households. They defend their analysis by claiming that the crowd-out effect only makes sense when one makes the assumption that households living in social housing could also live in privately owned dwellings. Based on this hypothesis, they show that the crowd-out effect is stronger in Turkey when social housing targets moderate-income households and not only low-income ones.

[Xu and Zhou \(2019\)](#) are interested in the impact of social housing construction on the vacancy rate in the private housing market. To perform this analysis, they use data from the Ministry of Internal Affairs and Communications of Japan, which survey more than 1000 municipalities in the country. In addition they focus on the 24 largest cities in Japan, where the majority of social housing construction is concentrated. Their results indicate that an increase in social housing construction implies an increase in the vacancy rate on the private market. Furthermore, they also observe this relationship when they focus only on the largest municipalities in the country. They argue that their results are driven by a type of market myopia ([Levitt, 1960](#)). They also claim that negative externalities also lead to an increase in the vacancy rate.

[Chapelle \(2014\)](#) assesses the crowd-out effect in France. To carry out his estimation, he uses data over two separate periods, from 1990 to 1999 and then from 2000 to 2009. He implements his study on various scales, whether they are geographical, intra-municipal, intra-EPCI or intra-urban. To address the endogeneity issue he uses using three instruments. He shows that his instrumentation method, whilst not being convincing on a small scale, is valid on a larger scale. By this mean he observes a crowd-out effect at the EPCI level. The distinctiveness of this analysis is that he detects very high estimates of the crowd-out effect, going from 1.1 to 1.8.

[Gobillon and Vignolles \(2016\)](#) assess the impact of the SRU law. In their contribution, they use data stemming from 2000 to 2008 for 1850 municipalities. The SRU law, among other features, requires that each municipality affected by the law, to have at least 20% of social housing. [Gobillon and Vignolles \(2016\)](#) take advantage of the fact that the SRU only applies to municipality of over 3500 inhabitants and does not concern smaller municipalities. In a discontinuity regression, they take into consideration municipalities with 6000 habitants or less. Their results seem to indicate that the “SRU law” played a part in a geographical scattering of social housing. They also highlight the slightly negative effect of the SRU on the housing prices on the property market in the municipalities who are the most behind in implementing the goals established by the SRU law. This last feature seem to indicate that there is a crowding out effect of the construction of social housing.

### 3 Mechanism

Building social housing can induce a crowd-out effect for a few main reasons. The mechanisms on display can appear at certain scales and not others. The first economic channel that can explain why the construction of social housing has an impact on the construction of private housing is the substitution effect. Social housing in France is accessible to an important portion of the national population. Indeed 60% of the French population qualifies for social housing ([Laferrère, 2011](#)). For this reason, when the amount of public accommodation increases and when their rents are lower than those in the private market, a portion of the population living in privately-owned dwellings decides to relocate to public housing. Under this reasoning, it is through the private rental housing market that social housing impacts the overall housing market. This mechanism is tricky to observe on small scales. Indeed, it is conceivable that individuals of neighboring areas are attracted by the construction of social housing. In other words, the building of social housing in a municipality can attract individuals from neighboring municipalities and increase the population. Henceforth, one cannot rule out the crowd-out effect because of the impact social housing has on the neighboring municipalities. In order to take this problem into consideration, it is useful to study the housing market as a whole. On this topic, [Chapelle \(2014\)](#) argues that the relevant scale is the inter-municipal one, a smaller scale could miss a part of the crowd-out effect.

Another channel of the crowd-out effect is the neighborhood effect. The proximity of public dwellings can generate negative amenities for the neighboring accommodations. Some studies based on the effect of LIHTC seem to indicate that building social housing changes the social recognition associated to each district. [Schively \(2007\)](#) explains that the existence of social housing lowers the appearance of exclusivity of a neighborhood. Other studies ([Schwartz et al., 2010](#); [Duke-Lucio et al., 2010](#)) show that the presence of social housing in a neighborhood diminishes the quality of the education dispensed. They also indicate that pupils from a same class, when living in LIHTC housing, show lower academic results. This result is however quite contested as another study ([Di and Murdoch, 2010](#)), with data from Texas, does not indicate a correlation between academic performance and living in a LIHTC dwelling. Finally, [Baum-Snow and Marion \(2009\)](#) show that housing close to LIHTC housing can also profit from positive amenities. Indeed when once empty LIHTC dwellings become inhabited, the authors notice that these dwellings are usually well kept and managed. [Baumont \(2007\)](#), to describe the importance of the neighborhood effect, uses a distance matrix, where a distance inferior to 250 meters is allocated a value of 1 and a distance superior to 250 meters a value of 0. Resorting to the distance matrix indicates that, when observing a crowd-out effect caused by a neighborhood effect, it is necessary to maintain a finer scale. Other channels also seem interesting when attempting to explain the crowd-out effect.

Chapelle (2014) notes that public housing builders are in competition with private housing builders on two levels, first of all when buying the land, second of all when obtaining the service of the construction industry. This competition to obtain the means of production for construction implies that an increase in public housing construction can entail a decrease of private housing construction. This channel of transmission can exist depending whether the means of production are lacking or not. Chapelle (2014) shows that 90 to 93% of the construction industry's potential has been harnessed on a period stemming from 2000 to 2010 in France at the national scale.

## 4 Empirical Strategy

The aim of this chapter is to assess the impact of the construction of social housing on the private market. In order to measure the prices on the private market, we use the prices of both houses and apartments. These prices are labeled by the variable  $Y_{ijt}$  for a transaction  $i$  in municipality  $j$  at time  $t$ . The variable measuring the construction of social housing  $X$  is built as the difference between the share of public housing at time  $t$  and at a time  $t-1$ . Furthermore in order to take into account the fact that municipalities have different sizes, we measure the proportion of social housing as the stock of social housing  $S$  on the stock of primary residence  $R$ .

$$X_{jt} = \frac{S_{jt}}{R_{jt}} - \frac{S_{jt-1}}{R_{jt-1}} \quad (1)$$

In other words the ratio  $\frac{S_{jt}}{R_{jt}}$  represents the proportion of social housing in a municipality, and the variable  $X$  measures the increase in percentage points of the proportion of social housing in a municipality; But such a measure does present limits. If on a same period there has been an equal number of social housing built and destroyed, the measure of the net construction is null. Moreover it is not possible to compute the variable otherwise than on a municipal level. This leads us to write the regression as follows

$$Y_{ijt} = \beta_0 + \beta_1 X_{jt} + \epsilon_{ijt} \quad (2)$$

Yet, this regression, which explains the price of private dwellings by the number of social housing units built, is subject to endogeneity issues. Indeed, both the construction of social housing and market prices can be influenced by common unobserved variables. Since  $X$  and  $Y$  are endogenous, the results of the previous regression would be biased. In order to correct this source of endogeneity we can use a quasi-natural experiment, namely the delegation of housing subsidies that affect the municipalities concerned by the SRU.

The Law on Urban Solidarity and Urban Renewal of 13/12/2000, more commonly abbreviated as SRU<sup>1</sup>, covers five major themes, one of which is central to our analysis: social diversity. This aspect of the law stipulates that municipalities of more than 3500 inhabitants and over 1500 in the Paris area (Île de France), must have at least 20% social housing units. When a municipality does not comply with this 20% objective it must pay a fine. This means that the SRU law must have an impact on the construction of social housing in the municipalities that are concerned given they are below the 20% threshold. On the other hand, municipalities with fewer than 3500 inhabitants, or those with more than 3500 inhabitants and more than 20% of social housing, are not, as a rule, encouraged to build more social housing. The other four parts of the law deal with minor aspects of the private housing market and most certainly have no consequences on the prices of private housing. It is therefore possible, with the features of this law, to benefit from a quasi-experimental design, which allows us to study municipalities that have been affected by the SRU and others not.

Table 1 – Number of municipalities in Greater Lyon Lyon divided into four categories, depending on the threshold of 3500 inhabitants and the threshold of 20% of social housing in 2009.

	< 20%	> 20%	Total
< 3500 inhabitants	13	3	16
> 3500 inhabitants	25	17	41
Total	38	20	58

Table 2 – Number of transactions in Greater Lyon divided into four categories, depending on the threshold of 3500 inhabitants and the threshold of 20% of social housing in 2009 municipal.

	< 20%	> 20%	Total
< 3500 inhabitants	1331	195	1526
> 3500 inhabitants	60055	31467	91522
Total	61386	31662	93048

However, as the coercive power of the law was weak at first, some of the municipalities were able to postpone the penalties they should have paid. In addition, the impact of the SRU law on the municipalities of Greater Lyon were not visible before financial means for social housing construction

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<sup>1</sup>The precise name of the law is : « loi no 20001208 du 13 décembre 2000 relative à la solidarité et au renouvellement urbains »

were granted. This was the case with a change in the institutional setting that occurred in 2006. From this moment, federations of municipalities (EPCI, acronym for établissement public de coopération intercommunale) may request a delegation of state competence in the production, rehabilitation and demolition of buildings; this agreement is concluded for 6 years. This delegation means that municipalities acquire public resources usually devoted to the social housing construction. It is only with the delegation of housing subsidies that the construction of social housing in the cities concerned by SRU took off. We make the assumption that the combined effect of the SRU and the delegation of the state competence and resources in the social housing construction, incentivized municipalities with low level of social housing to build more of them. The first plan of housing subsidies was implemented in 2006 but it was only at the beginning of 2009 that there was an acceleration in the construction of social housing in the cities concerned by the law that did not respect it. Indeed, this period corresponds to the lapse of time needed for the social housing units financed in 2006 to be built. This acceleration can be seen in figure 1.

#### 4.1 Regression discontinuity design

In order to deal with endogeneity, a regression discontinuity design can be used. The method is based on the existence of a selection variable which has a discontinuous impact on the probability of being treated. The goal of this method is therefore to find a "threshold" assignment rule. Intuitively, the individuals in the vicinity of this discontinuity are similar enough to be compared, the only difference being that some are subjected to public policy while others are not. With this method, two groups of individuals are compared, those below and those above a threshold.

To be implemented, a regression discontinuity design requires to check whether a precise hypothesis is valid, that of the continuity of the variable explained at the proximity of the discontinuity, in the absence of treatment. The validity of this hypothesis is crucial if we want to assess the causal impact of the policy. This means that if we observe a statistically significant discontinuity in regression discontinuity design, and that it is known that without treatment the variable is continuous, the discontinuity can be attributed to the treatment. In the literature, we observe that the closer municipalities are to the center of an agglomeration, the more densely populated they are and the more expensive their housing prices per square meter. This relationship is explained by [Alonso \(1964\)](#). We therefore make the hypothesis that amenities and the distance from the city center continuously affect the property prices. That's why we argue that the assumption of the continuity of the variable of interest in the absence of treatment is respected. This means that if a very specific difference is observed right at the threshold of 3500 inhabitants, there is nothing to suggest that this rupture exists in the absence of the SRU.

In a sharp design, when the definition of the threshold is explicit, as is the case for the SRU law, the identifying hypothesis is that in the vicinity of the point of discontinuity, the potential prices of treated and not treated transactions alike are continuous. It would require that housing prices diminish exactly at the 3500 inhabitants threshold to invalidate the regression discontinuity design validity.

However, in order for the method to produce consistent results, it is necessary to select a group of municipalities (considered to be) close enough to the 3500 threshold. This subsampling of the database is conducted to properly treat endogeneity. With this method, we are faced with a choice between keeping as many statistical individuals as available or restricting oneself to a pool of treated and non-treated as-similar-as-can-be individuals. In our analysis we consider three different subsamples, a first with municipalities with a population between 3000 and 4000, then one of population between 2500 and 4500 and finally a much larger with population between 1500 and 5500.

In addition, with a regression discontinuity design, it is necessary to check another hypothesis: that the individuals are really similar in the vicinity of the threshold of 3500 inhabitants. To verify this, it is possible to compare the characteristics of the transactions that took place above and below the threshold. Comparing the averages of housing characteristics makes it possible to observe whether or not major differences occur between the two groups. What we observe in table 6 is that, within the bracket of 1000 inhabitants around 3500, there are very few significant differences in characteristics, on average, between homes sold in municipalities below and above the threshold.

However, when considering the two wider brackets, more substantial differences appear. For this reason, it is necessary with the regression discontinuity design to take these variables into account as control variables, in order to obtain a more accurate estimate. The control variables that we include in the regression are annual and municipal fixed effects. The municipal fixed effects are included to capture any feature that are time invariant and specific to each municipality. These features can be the distance to the center, or the effect of amenities, or both, on housing prices. The annual fixed effects are included to capture any yearly specific effect that affects housing prices, for example a national decrease in prices that affects all housing sales in the Greater Lyon area. Dwellings characteristics are accounted for by including the number of rooms<sup>2</sup>, the average area of the rooms, a binary variable for apartments and houses, a binary variable when housing has more than one bathroom, a binary variable when the dwelling has a cellar and finally a parking lot.

To estimate the impact of the treatment, we use a local linear regression. In a local linear regression in a discontinuity design, two regressions are put in place, one on each side of the discontinuity. Hence, with this method there are two regression equations, one for the data on the right side of the

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<sup>2</sup>The number of rooms variable consists of several binary variables that measure whether the apartment consists of one bedroom, three bedrooms, four bedrooms, five bedrooms, or six or more bedrooms. Dwellings with two bedrooms are the reference category.



discontinuity  $r$ :

$$Y_{ijt} = \beta_{0r} + \beta_{1r}T_{jt} + \beta_{2r}C_{ijt} + \omega_j + \psi_t + \epsilon_{ijt} \quad (3)$$

and one for the data on the left  $l$  of the discontinuity:

$$Y_{ijt} = \beta_{0l} + \beta_{1l}T_{jt} + \beta_{2l}C_{ijt} + \omega_j + \psi_t + \epsilon_{ijt} \quad (4)$$

Where  $T_{jt}$  is a dummy variable for the municipality being above or below 3500 inhabitants. Hence  $\beta_1$  can be interpreted as the effect of the treatment on transaction prices.  $C_{ijt}$  represents a vector of specific housing characteristics, used as control variables. Indeed, housing units have multiple attributes that are differently valued. Thus, if the dwellings of some municipalities are actually larger, or more equipped with parking spaces, etc., it is possible that this disrupts the estimate of the effect of the treatment. Additionally, we also include municipality fixed effects  $\omega_j$  and annual effects  $\psi_t$  to take into account unobservable variables that are invariant for each municipality and for each year.

This method puts forward two coefficients  $\beta_{0r}$ ,  $\beta_{0l}$  and two coefficients  $\beta_{1l}$ ,  $\beta_{1r}$ . So as to estimate the impact, it is necessary to compare the predicted values for each of the two regressions at the proximity of the discontinuity. This solution presented by [Hahn et al. \(2001\)](#) is interesting because it checks that the estimated value of the constant for each of the regressions is not influenced by the property sales on the other side of the discontinuity. If we use only one regression to take into account the data on both sides of the discontinuity, the processed and untreated values would be used to estimate the model constant, a procedure that poorly matches discontinuity regression ([Lee and Lemieux, 2010](#)).

## 4.2 Difference-in-differences design

What the difference-in-differences design seeks to estimate is the gap between a hypothetical counterfactual and the group of treated individuals receiving the treatment.

Nevertheless, the treatment here is not binary. The incentive to build is all the greater as the municipality has a significant discrepancy with respect to the SRU objectives to catch up with. Indeed municipalities that do not respect the SRU objective of 20% of social housing are fined. The amount of the fine is determined by a calculation taking into account the number of housing units that lack to reach the 20% social housing target. The amount of the fine is the result of a multiplication between the number of missing housing units and an amount determined by law. Therefore the treatment intensity is greater as the discrepancy between the objectives and the actual number of social housing is higher. Conversely if the municipality is very close to 20%, the treatment will have little intensity.

The treatment intensity is the difference between objectives of the SRU and the actual proportion of social housing. The initial proportion of social housing we need to use is the one when the first

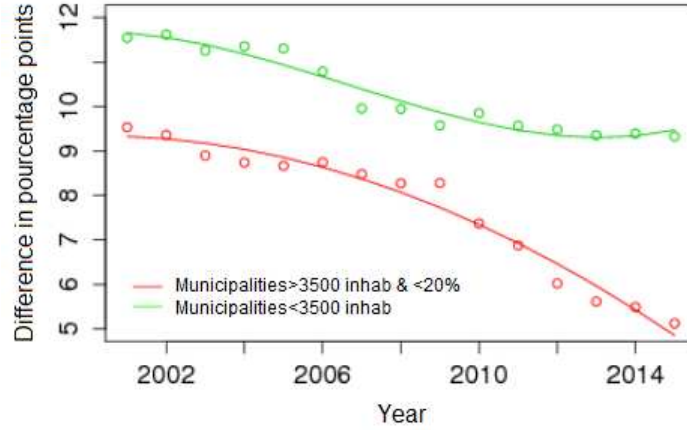


Figure 1 – Absolute difference between the SRU’s 20% objectives and the average proportion of social housing for the municipalities concerned and those not covered by the SRU.

housing units are erected, that is to say the one observed in 2006. It is this difference that allows us to measure the intensity of the treatment. Moreover, when dealing with a continuous treatment, we can focus on municipalities which are both concerned by the law and contravening it only. It means that in the sample we only consider the transactions of the municipalities of more than 3500 inhabitants, but also having less than 20% of social housing, that is, 25 municipalities.

Hence, the intensity of the treatment is defined as:

$$T_{j,t=2006} = 0.2 - \frac{S_{j,t=2006}}{R_{j,t=2006}} \quad (5)$$

We will estimate the following equation :

$$Y_{ijt} = \beta_0 + \beta_1 T_i D_t + \beta_2 T_i + \beta_3 D_t + \beta_4 C_{ijt} + \epsilon_{it} \quad (6)$$

$D_t$  is the temporal variable that takes value 1 for the post-2009 period and 0 otherwise. The coefficient of interest is  $\beta_1$ .

The effect of time on an individual receiving treatment  $\bar{T} + dT$  is expressed as:

$$E[Y_{it}|T_i = \bar{T} + dT, D_t = 1] - E[Y_{it}|T_i = \bar{T} + dT, D_t = 0] = \beta_1(\bar{T} + dT) + \beta_3 \quad (7)$$

The effect of time on an individual receiving treatment with a lower intensity  $\bar{T}$  is expressed as :

$$E[Y_{it}|T_i = \bar{T}, D_t = 1] - E[Y_{it}|T_i = \bar{T}, D_t = 0] = \beta_1 \bar{T} + \beta_3 \quad (8)$$

This allows us to write the effect of a marginal change in the treatment, that is, the effect of having a larger deficit of social housing as :

$$\begin{aligned} & (E[Y_{it}|T_i = \bar{T} + dT, D_t = 1] - E[Y_{it}|T_i = \bar{T} + dT, D_t = 0]) - \\ & (E[Y_{it}|T_i = \bar{T}, D_t = 1] - E[Y_{it}|T_i = \bar{T}, D_t = 0]) = \beta_1 dT \end{aligned} \quad (9)$$

According to this first regression, the construction of social housing induced by the introduction of subsidies has an impact  $\beta_1 T_i D_t$  on transaction prices  $Y_{ijt}$ .

The difference-in-differences design with continuous treatment is interpreted differently from classic difference-in-differences design. The way in which the classic difference-in-differences is implemented commonly consists of two groups, the treated group and the control group. Here in a difference-in-differences design with continuous treatment, all individuals receive the treatment but with a different intensity. So, the average effect of the treatment is equal to  $\beta_1$ ; it is interpreted as the difference between the average result of a group receiving a treatment intensity  $\bar{T}$  and another group of individuals receiving treatment intensity slightly different  $\bar{T} + dT$ .

One of the hypotheses of the difference-in-differences design is the common trend. This hypothesis states that the trend of the two groups of individuals would have been the same in the absence of treatment. This hypothesis can be verified because it is possible to observe the growth of the proportion of social housing by municipality, based on the initial proportion of social dwellings. This aspect is illustrated in figure 2.

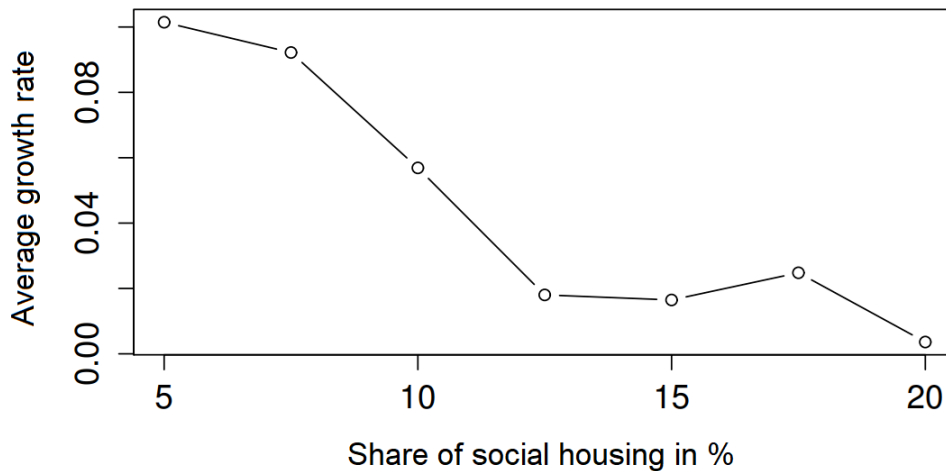


Figure 2 – Average growth rate between 2004 and 2014 of the proportion of social housing as a function of the initial municipal social housing proportion.

In order to observe whether the hypothesis of a common trend is reasonable or not, we can conduct a graphic analysis as a first approach. Figure 3 shows the evolution of housing prices in the 25 municipalities of Grand Lyon between 2004 and 2014 for four quartiles built based on the percentage of social housing present in the municipality in 2006. The purpose is to see if the prices of transactions follow the same trend before 2009 for each of the four groups. However, the sole graphical comparison of the averages for each of the four groups is not enough. As a matter of fact, it is possible that a group

with few social housing units is also the group of municipalities where housing is the most expensive because it is the largest. Therefore, it is important to compare averages while controlling for housing characteristics and location.

To do so, we run four regressions<sup>3</sup> with for each regression, the logarithm of the dwellings prices explained by the dwellings characteristics, and annual and municipal fixed effects. The four regressions are runned on four different subsamples, corresponding to the four quartiles in term of initial pourcentage of social housing. The first quartile is constituted of municipalities with the lowest pourcentage of social housing, and the last quartile is constituted with municipalities that are the closest to reach the objectives of the SRU law. In figure 3 we have allotted in a graph the coefficients of annual fixed effects. As these fixed effects are not influenced by the housing units' characteristics, this allows us to graphically observe whether the common trend hypothesis is likely or not. From this graphical representation, no different trends seem to show in the four different quartiles.

To formally test the common trend assumption, one can use a placebo test (Autor, 2003). To accomplish this, we include in the regression the interaction terms between year dummies (before 2009) and the number of social housing dwellings in 2006. The idea is to say that if it turns out that one of these interaction terms is statistically significant, then it means that we observe a change of trend this specific year. On the contrary, if none of the interaction terms preceding that of 2009 has a significant coefficient, we can conclude that we do not observe any statistically significant trend change and that the common trend hypothesis is not rejected.

Estimated placebo equation is :

$$Y_{ijt} = \beta_0 + \beta_1 T_i D_{2005i} + \beta_2 T_i D_{2006i} + \beta_3 T_i D_{2007i} + \beta_4 T_i D_{2008i} + \beta_5 T_i D_{2009i} + \epsilon_{ijt} \quad (10)$$

The results of regressions 10 are in table 10. The results suggest that there was no particularly noticeable change before 2009 except in 2008. This effect is present in regression 1 and 2. However these regressions do not take into account dwellings characteristics. In regression 3, in which we control for housing characteristics as much as possible, this effect disappear. This might seem to indicate that in 2008, the characteristics of the homes sold were on average different from the other years, and once we control for this effect, the interaction term of 2008 is no longer significant.

We only keep a portion of the housing sale price database in the difference-in-differences regression. Indeed, in order to measure the impact of continuous treatment, we only keep transactions that have occurred in contravening municipalities, in other words; the transactions which took place in municipalities of more than 3500 inhabitants and which have less than 20% of social housing. This means that observations used in the regression are not chosen randomly. It is therefore important

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<sup>3</sup>The regression formula is  $Y_{ijt} = \beta_1 X_{ijt} + \omega_i + \gamma_t + \epsilon_{it}$ . Each of the four regressions is performed on the four different quartiles subsamples

to take into account the potential bias that this selection may engender. First of all, the selection can impair the external validity of our results. We can still note that these results seem to indicate a negative relationship between social housing construction and transaction prices, results that seem to correspond to theoretical developments (Eriksen and Rosenthal, 2010), but also empirical ones (Gobillon and Vignolles, 2016). Another key point is that the results cannot be used to appraise the impact of a drop in the number of social housing units. The fact that social housing represents irreversible investments implies that the adjustment of the prices of private accommodation does not have the same amplitude when the number of social housing units is increasing or decreasing (Glaeser and Gyourko, 2005).

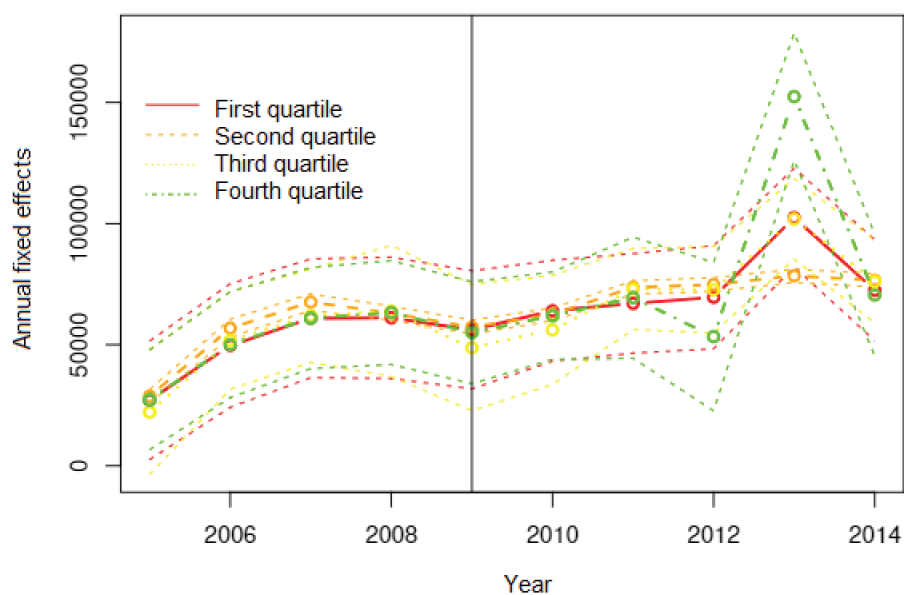


Figure 3 – Annual fixed effects for each of the 4 quartiles of municipalities (by % of public housing), in the estimation of property prices in Grand Lyon between 2004 and 2014.

## 5 Data and descriptive statistics

The real estate transaction price database comes from of the PERVAL database which comes from notaries records. In this database, we only focus on home sales, and therefore exclude the sales of entire buildings of several homes or land lots. There are 147,910 sales recorded over the period from 2004 to 2014, but we can only use 90,065 of them because many are incomplete. Each sale is located at the municipality level. The location at IRIS 8 is recorded only in 2013 and 2014, which is the reason why we cannot use it for every year. For each housing unit, we are also provided with information on the number of rooms, the total floor area, the number of specific rooms such as bathrooms and basements and the number of parking spaces as well. In addition, we also know the price of the property, and if the property is an apartment or a house.

The descriptive statistics are presented in table 3. The average price per square meter in the database is 2,844 euros. This value is higher than the median price, which indicates that the average is driven up by extreme values. The average area is 74.2 square meters. On the territory of Greater Lyon, the average number of rooms is slightly superior to 3 and the average room area is 23 square meters. Most of the dwellings have only one bathroom, about one out of every two dwellings has access to a cellar, and about 80% have a parking space. The majority of transactions that take place in the Greater Lyon area concern 2-, 3- and 4-room apartments. Smaller units represent only a small share of sales, as do units with 5 rooms or more. The results of these descriptive statistics are presented in 4.

Table 3 – Descriptive statistics of the entire PERVAL database

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Price in euro	10000	131000	177710	205300	245663	2160880
Price per m <sup>2</sup>	30.29	2216	2734	2844	3357	9954
Room sizes in m <sup>2</sup>	6.0	51.0	69.0	74.2	89.0	6632.0
Mean size of rooms in m <sup>2</sup>	2.66	19.80	22.25	23.11	25.00	178.000
Number of rooms	1	2	3	3.276	4	20
Number of bathrooms	0	1	1	1.1	1	10
Number of cellars	0	0	1	0.5353	1	9
Number of parking lots	0	0	1	0.8502	1	10
% of flats	-	-	-	0.8885	-	-

These descriptive statistics (tables 4 and 3) concern the 90065 dwellings in the PERVAL database over the period 2004-2014. They cover the 59 municipalities of the Greater Lyon area.

In table 6, we present descriptive statistics of transactions taking place in municipalities belonging to three different bracket groups: 1000, 2000 and 4000 inhabitants<sup>4</sup>. Populations of municipalities

<sup>4</sup>The INSEE data for the municipalities' population are calculated in two different ways depending on their counting

Table 4 – Number of transactions per type of dwellings

Number of rooms	Number of transactions
1 room	8404
2 rooms	19291
3 rooms	26574
4 rooms	22427
5 rooms	10746
6 rooms or more	2623
Total	90065

These descriptive statistics (table 5) concern the 90065 dwellings sold over the period 2004 to 2014 in the Greater Lyon area.

Table 5 – Descriptive statistics specifically for difference-in-difference sample

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Price in euro	10000	138740	192500	222839	269500	2160880
Price per m <sup>2</sup>	30.29	2380	2905	3037	3544	9954
Room sizes in m <sup>2</sup>	6.0	50.0	70.0	75.4	91.0	3564.0
Mean size of rooms in m <sup>2</sup>	2.66	20.00	22.67	23.59	25.67	178.000
Number of rooms	1	2	3	3.261	4	20
Number of bathrooms	0	1	1	1.116	1	7
Number of cellars	0	0	1	0.565	1	9
Number of parking lots	0	0	1	0.8325	1	10
% of flats	-	-	-	0.9004	-	-

These descriptive statistics (table 5) concern the 58853 dwellings from municipalities with more than 3500 inhabitants and which have less than 20% of social housing over the period 2004 to 2014.

with less than 10,000 inhabitants are obtained by linear interpolation when there has been no survey in the year (INSEE, 2008).

The average price per square meter is higher in municipalities that have a population around 3500 inhabitants than in the entire database. It can also be noted that the rooms of these dwellings are more spacious and are generally more numerous than in the entire database. It is also worth noting that if differences exist between dwellings sold in a bracket of 1000 inhabitants around the threshold of 3500, they are insignificant. By contrast, the larger the bracket is, the more significant the differences are.

The social housing database, comes from Grand Lyon. It measures the absolute number of social housing units, but also the ratio of social housing units to the total number of dwellings. As for the number of principal residences it comes from the INSEE population census. In this database, the number of social housing units is calculated at the municipality level for years 2000 to 2014. It contains data for 54 complete communes over 14 years of census.

In 2006, the municipalities that show the highest rates of social housing were mainly the municipalities on the eastern part of the agglomeration of Lyon. Vaulx-en-Velin, Meyzieu, Venissieux and Saint-Fons are the municipalities that had the highest percentages of social housing. Conversely, the municipalities with the lowest rates are the western municipalities. Saint-Cyr-au-Mont or Sainte-Foy-Lès-Lyon are among the municipalities with the lowest rates. The geographical distribution of the proportion of social housing in 2006 in the Greater Lyon area is shown in 4. The list of municipalities of each subsamples are displayed in table 12 and 13 in appendix 1 and 2.

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more or less than 10,000 inhabitants. When the population exceeds 10,000 inhabitants, an exhaustive census of the population is conducted every 5 years. As for the municipalities with less than 10,000 inhabitants, 40% of the population is surveyed in 5 years.



Table 6 – Mean difference test

	< 3500	> 3500	Diff
bracket : 3000 to 4000 inhabitants			
Price in euro	281098	271256	9842
Price per m <sup>2</sup>	2920	2837	83
Number of rooms	4.18	4.08	0.1
Mean size of rooms in m <sup>2</sup>	25.01	24.22	0.79***
More than one bathroom	0.049	0.047	0.0002
At least one cellar	0.0062	0.0039	0.0023
At least one parking lot	0.22	0.21	0.01
Observations	2218		
bracket : 2500 to 4500 inhabitants			
Price in euro	288248	282720	5528
Price per m <sup>2</sup>	2914	2910	4
Number of rooms	4.26	4.10	0.16***
Mean size of rooms in m <sup>2</sup>	25.05	24.11	0.94***
More than one bathroom	0.051	0.045	0.006
At least one cellar	0.0052	0.0071	-0.0019
At least one parking lot	0.22	0.23	-0.01
Observations	3999		
bracket : 1500 to 5500 inhabitants			
Price in euro	287353	263241	24112***
Price per m <sup>2</sup>	2897	2788	109***
Number of rooms	4.26	3.95	0.31***
Mean size of rooms in m <sup>2</sup>	25.00	23.96	1.04***
More than one bathroom	0.049	0.042	0.0007
At least one cellar	0.0046	0.0066	-0.002
At least one parking lot	0.24	0.21	0.03**
Observations	6273		
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01		

*Statistical individuals are individual sales on the private market. The sales are those of Greater Lyon over the period 2004-2014. These statistics are compiled with three different brackets; 1000, 2000, 4000 around the threshold of 3500 inhabitants. The sales are those of 13, 20 and 28 municipalities.*

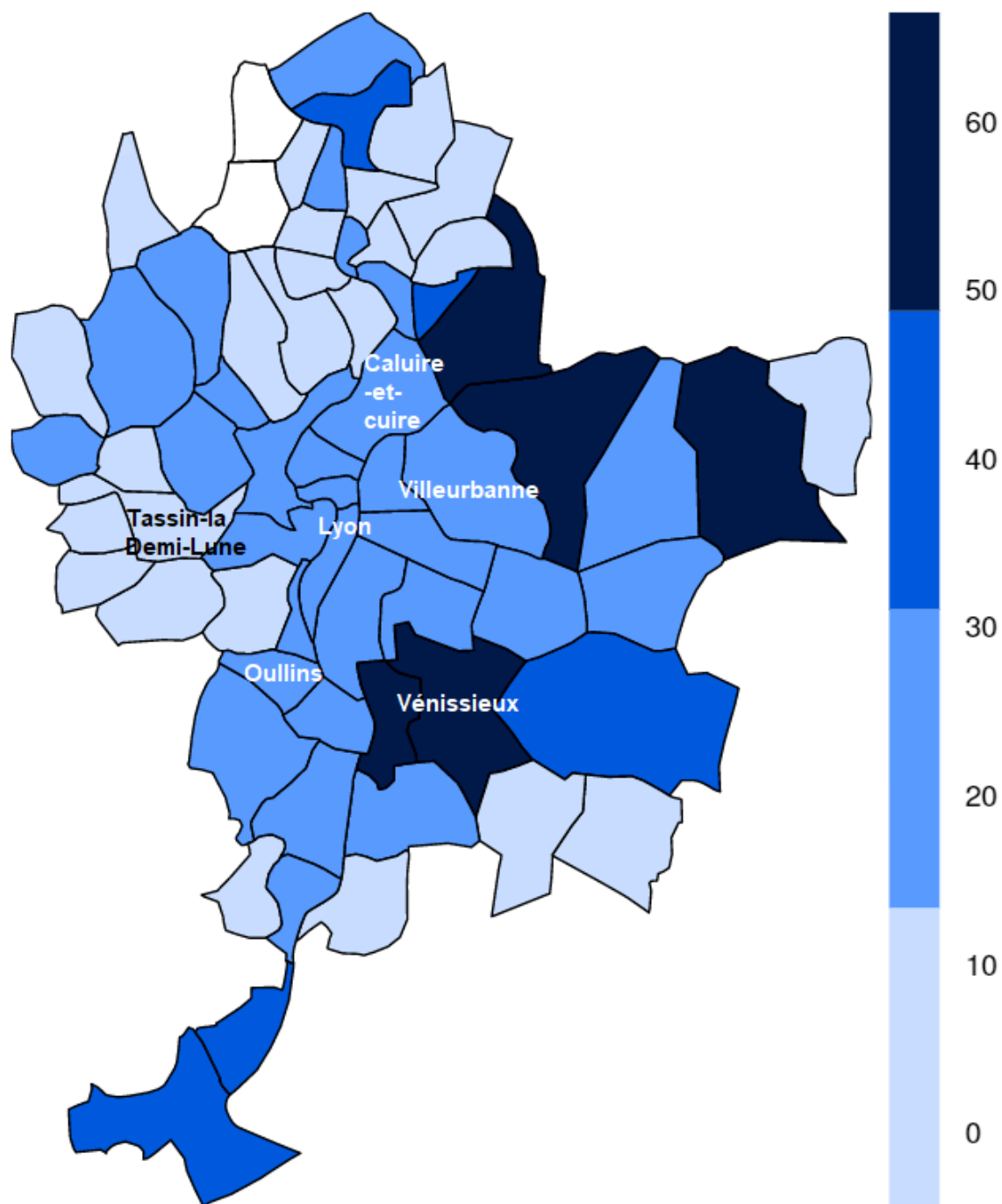


Figure 4 – Proportion of social housing in 2006 by municipality.

The SRU law and the subsidies are two public policies set up in favour of the development of social housing. However, the object of this study is to know whether the construction of social housing units has an effect on the prices of private dwellings. It is necessary to check that the policies mentioned

above are actually correlated with a rise in the construction of social housing. In other words, we have to check that the difference between the SRU objectives and the actual proportion of social housing of the municipality can be considered as an approximation of the real construction of social housing. For this reason, it is not enough to regress the level of social housing compared to the delay in 2006. Such a measure would only show a rise or fall in the supply of social housing. To see if there has been an acceleration of the construction of social housing units, it is necessary to use the growth rate of the percentage of social housing. In table 7, we try to verify that the deficit of social housing in relation to the objectives of the SRU is correlated with an increase in social housing construction. Thus, we regress the growth rate of social housing share on percentage growth rate on the deficit of social housing in 2006. This regression is carried out at municipal level and over the period 2004 to 2014. The results, displayed in table 7, show that there is a positive and significant relationship between the rate of the growth of the proportion of social housing and the deficit in 2006. To judge the validity of a proxy, special attention is paid to the significance of the variable, or the Fischer test. The significance of the variable is high and the Fischer test is statistically significant. However, if we take into account the fixed annual effects, the result of the Fischer test is significant but below the commonly accepted threshold of 10. The threshold of 10 is generally a commonly accepted value for assessing the explanatory character of a proxy. Nevertheless, the adjusted R2 is lower when we include the fixed annual effects, which indicates a regression with less precision. These results suggest that the constraint imposed by the SRU law on the municipalities the most behind the schedule encouraged them to build more social housing than those where the deficit was lower.

Table 7 – Estimation of the relationship between the objective of the SRU and the effective construction of social housing

	<i>Explained variable: Growth in the proportion of social housing</i>	
	(1)	(2)
Difference in 2006	0.007*** (0.002)	0.007*** (0.002)
2005		-0.027 (0.096)
2006		-0.053 (0.097)
2007		-0.101 (0.096)
2008		-0.036 (0.095)
2009		-0.016 (0.094)
2010		0.016 (0.094)
2011		-0.017 (0.094)
2012		0.131 (0.093)
2013		0.034 (0.093)
2014		-0.039 (0.093)
Constant	0.010 (0.025)	0.018 (0.070)
Observations	246	246
R <sup>2</sup>	0.045	0.077
R <sup>2</sup> Adjusted	0.041	0.034
Residual Std. Error	0.310 (df = 244)	0.312 (df = 234)
Test F	11.527*** (df = 1; 244)	1.781* (df = 11; 234)
<i>Note:</i>	* p<0.1; ** p<0.05; *** p<0.01	

*The statistical individuals in this regression are municipalities. The communes used are those of the double difference regression with continuous treatment over the period 2004-2014. No municipal fixed effects are included because the variable "Difference in 2006" is fixed in time for each municipality.*

## 6 Results

### 6.1 Regression discontinuity design

The first results of regression discontinuity design shown in table 8 and 9 seem to indicate that there is a statistically significant gap in housing prices at the 3500 inhabitants threshold. Through six discontinuity regressions specifications, it is possible to observe the effect on the logarithmic price and the price per m<sup>2</sup> of dwellings taking into account three bracket estimates; 1000 (2500-4500), 2000 (1500-5500) and 4000 (0-7500) inhabitants. For the three regressions estimating the log price, presented in the table 9, it is first noted that the regressions without control variables (1), (3), (5), all indicate a positive effect of the treatment on the log price, regardless of the bracket. This first result is surprising because a positive result goes against our expectations. However, when using control variables, the coefficients estimated for regressions (2) and (6) are negative. With the exception of the coefficients estimated in the regression (4), when controls for housing characteristics and municipality fixed effects are used, the results point in the expected direction. Moreover, the coefficient estimated in regression (4) is positive but much smaller than the coefficient estimated without control variables in regression (3).

Moreover, if we use the prices per square meter and no longer the log price, we get results that seem to indicate a differential at the threshold of 3500 inhabitants. Whatever the bracket, with or without control variables, the coefficient estimated is negative and statistically significant in each of the regressions. The amplitude of the differential, however, is smaller if we consider the bracket of (0-7500) inhabitants in regression (5), but it remains negative and statistically significant. This analysis therefore seems to indicate that the construction of social housing negatively affects housing log prices for small municipalities when controlling for housing characteristics in the bracket of (2500-4500) and (0-7500) inhabitants and the price per square meter for every bracket considered. These results seem to be partly in line with those of [Gobillon and Vignolles \(2016\)](#) who note that municipalities between 3500 and 6000 inhabitants, and that are the most behind SRU objectives, are denoted by statistically lower house prices than sales in municipalities under 3500 inhabitants.

Table 8 – Discontinuity regressions; log of transaction prices

Bandwidth	<i>Explained variable: price log</i>					
	<i>(2500-4500)</i>		<i>(1500-5500)</i>		<i>(0-7500)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
More than 3500 inhabitants	0.138*** (0.001)	-0.041*** (0.001)	0.271*** (0.002)	0.032*** (0.002)	0.084*** (0.002)	-0.037*** (0.001)
Municipals fixed effects		✓		✓		✓
Annuals fixed effects		✓		✓		✓
Housing characteristics		✓		✓		✓
Number of municipalities	13	13	20	20	28	28
Observations	2302	2302	4083	4083	6357	6357
F-statistics	12.93	289.1	16.80	218.3	32.31	395.2
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01					

The statistical individuals in this regression are individual sales on the private market. The sales used are those in Greater Lyon over the period 2004-2014. The discontinuity regressions use the threshold of 3500 inhabitants. These estimates are made with three different brackets; 1000, 2000, 4000. This means, for the brackets of 1000 inhabitants, that sales in municipalities with 2500 to 4500 inhabitants are used. In this regression, two municipalities pass the threshold of 3500 inhabitants during the period 2004 to 2014. These are the municipalities of La Tour-de-Salvagny and Marcy-l'Etoile.

Table 9 – Discontinuity regressions; prices per square meter

Bandwidth	<i>Explained variable: transaction prices per square meter</i>					
	<i>(2500-4500)</i>		<i>(1500-5500)</i>		<i>(0-7500)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
More than 3500 inhabitants	-279.4*** (0.728)	-237.3*** (1.990)	-206.1*** (2.485)	-206.8*** (4.504)	-93.1*** (3.176)	-233.4*** (1.265)
Municipals fixed effects		✓		✓		✓
Annuals fixed effects		✓		✓		✓
Housing characteristics		✓		✓		✓
Number of municipalities	13	13	20	20	28	28
Observations	2302	2302	4083	4083	6357	6357
F-statistics	20.71	21.02	17.30	15.03	17.54	30.42
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01					

The statistical individuals in this regression are individual sales on the private market. The sales used are those of Greater Lyon over the period 2004-2014. The discontinuity regressions use the threshold of 3500 inhabitants. These estimates are made with three different brackets; 1000, 2000, 4000. This means, for the brackets of 1000 inhabitants, that sales in municipalities with 2500 to 4500 inhabitants are used. The annual and municipal fixed effects as well as the distance to the centre are presented in the table ???. In this regression two municipalities pass the threshold of 3500 inhabitants during the period 2004 to 2014. These are the municipalities of La Tour-de-Salvagny and Marcy-l'Etoile.

## 6.2 Difference-in-differences design

We present four different specifications, using the double difference method with continuous treatment. For each of these specifications, we present the results with both with and without clustered standard errors at the municipal level. The reason we are doing this clustering is that the observations are transactions but the variable measuring the gap with the objectives of the SRU is calculated at the municipal level.

First of all, the first result shown in table 11 we can put forward, is that coefficient  $\beta_1$  is significant and positive in regressions (1) and (2). It means that the municipalities with a low share of social housing are where the prices are consequently higher. However the relation is non-significant when dwellings control are included in regressions (5) and (6).

Another interesting coefficient is  $D$ , measuring the impact of post-2009  $D$ . It is positive and statistically significant, which is, once again, an expected result. Indeed, the period that extends from year 2000 until year 2008 is often characterized by a significant rise in prices of real estate sales. The positive and significant result seems robust with or without clustering the error terms.

Finally, the term interaction  $\bar{T} \times D$ , which is used to reckon whether the policy in question had an effect on transaction prices, is of the expected and statistically significant sign when controlling variables are included in the regression. It is also interesting to note that the estimated coefficients vary little in their amplitude, with or without control variables. The most complete estimate (8), shows that a one-point increase of the term of interaction, implies a decrease of 0.003 of the logarithm of the transaction price. In other words, the constraints of housing construction imposed by the SRU and subsidies, have led to a drop in the prices of private dwellings in areas where delays regarding SRU objectives were great.

We can also note the particular case of the Decines-Charpieu municipality which is a municipality of more than 3500 inhabitants which during the years 2008 and 2009 has a social housing rate of 19.99%. For this reason, Decines-Charpieu appears in the regression only for two years. Because from then on, its social housing rate exceeds 20%.



Table 10 – Estimation with placebo to test the common trend hypothesis

	<i>Explained variable : log(price)</i>				
	<i>Cluster robust</i>	<i>Cluster robust</i>	<i>Cluster robust</i>	<i>Cluster robust</i>	<i>Cluster robust Without Lyon</i>
	(1)	(2)	(3)	(4)	(5)
Continuous treatment $\bar{T}$	-0.038*** (0.006)				
After 2005 $D$	-0.079*** (0.027)				
After 2006 $D$	-0.141*** (0.008)				
After 2007 $D$	0.017 (0.013)				
After 2008 $D$	0.017 (0.016)				
After 2009 $D$	-0.054*** (0.010)				
Placebo in 2005 $\bar{T} \times D$	-0.002 (0.005)	-0.001 (0.004)	0.002 (0.003)	0.002 (0.003)	0.005* (0.003)
Placebo in 2006 $\bar{T} \times D$	-0.003 (0.003)	-0.005 (0.003)	-0.006 (0.004)	-0.006 (0.004)	-0.010*** (0.004)
Placebo in 2007 $\bar{T} \times D$	0.0002 (0.003)	-0.0004 (0.003)	0.003 (0.003)	0.003 (0.003)	0.004 (0.004)
Placebo in 2008 $\bar{T} \times D$	-0.007** (0.003)	-0.007** (0.003)	-0.001 (0.002)	-0.001 (0.002)	0.001 (0.003)
Placebo in 2009 $\bar{T} \times D$	-0.001 (0.003)	-0.001 (0.002)	-0.005** (0.002)	-0.002 (0.002)	-0.002 (0.004)
Placebo in 2010 $\bar{T} \times D$				0.0005 (0.002)	-0.001 (0.003)
Placebo in 2011 $\bar{T} \times D$				-0.002 (0.003)	0.002 (0.003)
Placebo in 2012 $\bar{T} \times D$				0.004* (0.002)	0.001 (0.002)
Placebo in 2013 $\bar{T} \times D$				0.0002 (0.002)	-0.003 (0.003)
Placebo in 2014 $\bar{T} \times D$				-0.002 (0.002)	-0.005 (0.004)
Municipal fixed effects		✓	✓	✓	✓
Annual fixed effects		✓	✓	✓	✓
Dwelling characteristics			✓	✓	✓
Observations	58,853	58,853	58,853	58,853	20,651
R <sup>2</sup>	0.049	0.083	0.567	0.567	0.638
Ajusted R <sup>2</sup>	0.049	0.082	0.566	0.567	0.637
Residual Std. Error	0.522 (df = 58841)	0.512 (df = 58803)	0.352 (df = 58793)	0.352 (df = 58788)	0.312 (df = 20587)

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01

The data used are the same as in the difference-in-differences design with the continuous treatment. They concern sales taking place in municipalities with more than 3500 inhabitants and less than 20% of social housing over the sample period 2004-2014. Since treatment is not a variable calculated on the same scale as statistical individuals, standard errors are clustered at the municipality and calculated à la White.

Table 11 – difference-in-differences estimation with continuous treatment

	Variable explained: price log							
	OLS	cluster robust	OLS	cluster robust	OLS	cluster robust	OLS	cluster robust
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Continuous treatment $\bar{T}$	0.037*** (0.001)	0.037*** (0.004)			0.001 (0.001)	0.001 (0.004)		
After 2009 $D$	0.171*** (0.009)	0.171*** (0.016)			0.275*** (0.006)	0.275*** (0.010)		
Continuous interaction term $\bar{T} \times D$	-0.010*** (0.002)	-0.010*** (0.003)	-0.012** (0.001)	-0.012** (0.002)	-0.006*** (0.001)	-0.006*** (0.002)	-0.006*** (0.001)	-0.006*** (0.002)
Municipal fixed effects			✓	✓			✓	✓
Annual fixed effects			✓	✓			✓	✓
Dwelling characteristics					✓	✓	✓	✓
Constant	12.135*** (0.004)	12.135*** (0.047)	11.966*** (0.017)	11.966*** (0.027)	11.858*** (0.008)	11.858*** (0.036)	11.837*** (0.014)	11.837*** (0.055)
Observations	58,853	58,853	58,853	58,853	58,853	58,853	58,853	58,853
R <sup>2</sup>	0.046	0.046	0.082	0.082	0.536	0.536	0.567	0.533
R <sup>2</sup> Adjusted	0.046	0.046	0.081	0.081	0.536	0.536	0.566	
0.533								
Residual Std. Error	0.522 (df = 58849)	0.522 (df = 58849)	0.513 (df = 58807)	0.513 (df = 58807)	0.365 (df = 58839)	0.365 (df = 58839)	0.352 (df = 58797)	0.366 (df = 58798)
Note:							*p<0.1; **p<0.05; ***p<0.01	

In this regression only the sales that took place in an affected municipality and that contravened the law are kept. This means that the 59656 sales used in these regressions come from municipalities with more than 3500 inhabitants and which have less than 20% of social housing over the period 2004 to 2014. Since treatment is not a variable calculated on the same scale as statistical individuals, standard errors are clustered to the municipality and calculated à la White.

## 7 Conclusion

In conclusion we can note that through two methods we have put into light the impact of the construction of social housing financed by the subsidies in municipalities subject to the SRU law. The regression discontinuity design concerning the municipalities with a population around 3500 inhabitants shows that the sales in municipalities concerned by the SRU are statistically less expensive than those not concerned by the law. This link is all the more significant when taking into account housing characteristics. This result seems to go corroborate those of [Gobillon and Vignolles \(2016\)](#). Nevertheless, with this method we only take into consideration small municipalities, those close to the 3500 threshold inhabitants. With difference-in-differences design and using a continuous treatment one can focus on larger municipalities. Indeed, in the sample that we use in this method, we keep the affected and non-affected municipalities. In the same way our results seem to indicate that the construction of social housing has a negative impact on prices. However, this does not necessarily mean that housing prices go down in these cities. Indeed, the results show that housing prices are rising in the agglomeration. But they nevertheless show that a municipality which has fallen far behind the objectives of the SRU saw its private housing prices rise at a slower pace because it was forced into building social housing. In other words, our results suggest that the construction of social housing has partially curbed the rise in private housing prices. To go further in this analysis, it might be relevant to use data which locate geographically and more accurately social housing construction. Obviously, it is likely that the quality of the estimate would be better if we could use data at an infra-communal level. It could also be very interesting to have data about the type and the quality of social housing. The effect of social housing might be different depending on whether social housing is highly concentrated or whether it is more evenly distributed. Indeed, in Grand Lyon there is a large variety of social housing, however the existing databases do not discriminate these dwellings in terms of quality.

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## 8 Appendices

### 8.1 Appendix 1

Table 12 – List of municipalities used for discontinuity regression and their population in 2012 and the number of sales from 2004 to 2014.

<i>Municipality</i>	<i>Population in 2006</i>	<i>% of Social housings in 2004</i>	<i>% of Social housings in 2014</i>	<i>% of variation</i>	<i>Number of sales</i>
Curis-au-Mont-d'Or	911	6.10%	6.12%	+0.3%	40
Saint-Romain-au-Mont-d'Or	1093	4.61%	6.71%	+45%	58
Rochetaillée-sur-Saône	1264	22.46%	22.91%	+2%	84
Fleurieu-sur-Saône	1300	4.11%	3.72%	-9%	59
<i>Sathonay-village</i>	1849	2.94%	4.85%	+65%	147
<i>Cailloux-sur-Fontaines</i>	2288	1.57%	2.18%	+39%	107
<b>Solaize</b>	2527	2.67%	2.04%	-23%	132
<b>Couzon-au-Mont-d'Or</b>	2570	10.57%	10.7%	+1%	101
<b>Montanay</b>	2661	3.11%	6.451%	+107%	96
<b>Fontaines-Saint-Martin</b>	2702	10.13%	9.57%	-5%	133
<b>Albigny-sur-Saône</b>	2726	26.66%	28.91%	+8%	106
<b>Limonest</b>	3007	14.04%	15.73%	+12%	265
<b>Marcy-l'Étoile</b>	3218	14.30%	18.80%	+31%	117
<b>Lissieu</b>	3307	2.41%	3.16%	+31%	233
<b>La-Tour-de-Salvagny</b>	3467	4.08%	9.02%	+121%	222
<b>Collonges-au-Mont-d'Or</b>	3775	0.38%	6.96%	+1731%	266
<b>Sathonay-Camp</b>	4171	34.29%	28.85%	-16%	304
<b>Charly</b>	4183	0.83%	3.08%	+271%	187
<b>Vernaison</b>	4320	26.16%	25.51%	-2%	220
<i>Saint-Genis-les-Ollieres</i>	4667	6.24%	10.64%	+71%	234
<i>Genay</i>	4726	18.16%	18.07%	+0%	248
<i>Charbonnières-les-Bains</i>	4835	6.54%	9.89%	+51%	339
<i>Champagne-au-Mont-d'Or</i>	4961	13.93%	18.96%	+36%	469
<i>Saint-Cyr-au-Mont-d'Or</i>	5388	4.34%	9.12%	+110%	166
Saint-Didier-au-Mont-d'Or	6340	2.23%	3.64%	+63%	256
Neuville-sur-Saône	7093	31.66%	29.67%	-6%	415
Fontaines-sur-Saône	6337	25.73%	20.77%	+24%	624
La Mulatière	6580	21.08%	21.52%	-2%	572

When the name of the municipality is in bold, it is included in the bracket of 1000 inhabitants. When the name of the municipality is in italics, it is included in the bracket of 2000 inhabitants. When the name of the municipality is neither bold nor italicized, it is included in the bracket of 4000 inhabitants. The population is the one counted by INSEE in 2012, the most recent census conducted by INSEE. The number of sales corresponds to sales for the 2004-2014 period. The data for sales comes from the PERVAL database.

## 8.2 Appendix 2

Table 13 – List of municipalities used for the regression in difference-in-differences design with their population, the percentage of social housing in 2012 and the number of sales from 2004 to 2014.

<i>Municipality</i>	<i>Population</i>	<i>% of social housing in 2004</i>	<i>% of social housing in 2014</i>	<i>% of variation</i>	<i>Number of sales</i>
Marcy-l'Étoile	3503	14.3%	18.8%	+31%	117
La-Tour-de-Salvagny	3851	4.08%	9.02%	+121%	222
Collonges-au-Mont-d'Or	3860	0.38%	6.96%	+1731%	266
Charly	4470	0.83%	3.08%	+271%	187
Saint-Genis-les-Ollieres	4563	6.24%	10.64%	+70%	234
Charbonnieres-les-Bains	4851	6.54%	9.89%	+51%	339
Genay	5181	18.16%	18.07%	-0.5%	248
Champagne-au-Mont-d'Or	5254	13.93%	18.96%	+36%	469
Saint-Cyr-au-Mont-d'Or	6403	4.34%	9.12%	+110%	166
Dardilly	8519	13.93%	18.28%	+31%	482
Chassieu	9800	14.09%	16.57%	+17%	574
Craponne	10165	10.98%	15.62%	+42%	867
Corbas	11023	10.36%	13.79%	+33%	599
Mions	12233	11.71%	15.08%	+28%	880
Francheville	13599	11.28%	18.23%	+61%	1238
Ecully	17742	18.19%	19.59%	+7%	1193
Saint-Genis-Laval	20632	16.69%	17.16%	+3%	1282
Tassin-la-Demi-Lune	21024	9.77%	12.59%	+28%	2197
Sainte-Foy-les-Lyon	21707	9.41%	12.32%	+31%	1878
Oullins	25896	16.47%	17.03%	+3%	2130
Meyzieu	31493	18.48%	18.99%	+3%	2099
Caluire-et-Cuire	42038	15.55%	17.42%	+12%	3356
Lyon	496343	18.14%	19.76%	+9%	38749

The population statistics are provided by the INSEE from its last population census. The percentage of social housing in 2012 comes from the Greater Lyon databases. *La population est celle enregistrée par l'Insee en 2012, dernier recensement réalisé par l'Insee. Le pourcentage de logements sociaux en 2012 provient des bases de données du Grand Lyon. Le nombre de ventes correspond au chiffre d'affaires de la période 2004-2014. Les données relatives aux ventes proviennent de la base de données PERVAL.* The population statistics are provided by the INSEE from its last population census. The percentage of social housing in 2012 comes from the Greater Lyon databases.

## Chapter 3 :

### Housing prices, ownership incentives and rent control:

#### Evidence from France

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##### *Abstract*

This paper studies the relevance of ownership incentives to improve housing affordability in a metropolitan area where rent control is imposed. We develop a theoretical model in which owners of new housing benefit from either a homeownership incentive or a rental investment incentive. We show that both incentives reduce the second-hand housing prices and increase the new housing prices. These effects are amplified when a rent control is imposed. We empirically test these findings by exploiting a 2014 French reform in the metropolitan area of Lyon which intensified both incentives. Difference-in-difference estimate confirms the theoretical predictions. Moreover, our results suggest that the intensification of these housing ownership incentives improves the overall housing affordability and that this effect amplified by rent control.

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## 1 Introduction

While housing is a fundamental human need and is considered a human right in many national constitutions and international bodies of human right such as the Charter of Fundamental Rights of the European Union, the lack of access to affordable housing is a persistent concern in the world metropolitan areas. On average, across the OECD countries, 25% of owner-occupants with a mortgage and 31% of private market tenants are overburdened by housing expenditures that is, their housing costs exceed 40% of their disposal income (Salvi del Pero et al., 2016). These excessive costs result in a range of harms to city dwellers such as overcrowded dwellings, children's poor performance in school and transitional homelessness (Busch-Geertsema et al., 2010).

These critical issues have placed access to affordable housing at the core of housing market regulation in many countries. OECD (2016) surveyed 26 countries and reports that all mention support to housing access as one of the five most important objectives of housing policy. In practice, affordable housing accessibility is addressed by governments through the mix of a variety of housing policy instruments such as tax relief for access to homeownership, subsidized mortgage and rent control, among many others (see OECD, 2016). Whereas they are commonly gathered under the term 'housing policy', these instruments are actually extremely diverse according to their nature (tax rebates, social rental housing, allowances in cash and vouchers, rent guarantees, etc.), the tenure they target (rental housing or owner-occupied housing) and whether they focus on the demand-side of the market (housing consumers: tenants and home buyers) or on the supply-side of the market (landlords, developers and investors who purchase or build housing).<sup>1</sup>

This critical diversity of the countries' housing policy instruments calls into question their ability to provide a coherent response to unaffordable housing. One could indeed wonder if some instruments mitigate the effects of others and if all the instruments optimally interact to promote affordable housing. Existing contributions on the topic have most often focused on the effect of a single instrument. This makes it difficult to obtain a reliable picture of the effectiveness of the exiting rich sets of housing policy instruments to tackle housing unaffordability in metropolitan areas. This paper provides insights into the combined effects of several standard instruments of housing policy on housing affordability.

Specifically, the paper investigates the effects on housing prices of the two different forms of public support to housing ownership: homeownership incentives and support to rental investment. Moreover, the paper studies the relevance of these two types of policy instruments in terms of housing affordability when rent control prevails.

Few is known about the effects on housing affordability of providing incentives to homeownership and rental investment when rent control is imposed. However, these three tools are typical in gov-

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<sup>1</sup>See Salvi del Pero et al. (2016) for further details.

ernments' set of housing policy instruments. While some countries are reportedly tenure-neutral (e.g. Poland, Switzerland and Turkey), most OECD countries provide more significant support to homeownership than to other tenures (Salvi del Pero et al., 2016). Homeownership is indeed usually perceived as having economic and social benefits due to housing stability such as better children education and deeper involvement in one's community (Glaeser, 2011). Rental investment which allows to supplement workers' wage and elder peoples' pension, is also supported in a number of OCED countries such as Australia, Germany and Finland (De Boer and Bitetti, 2014). As to tenancy protection, among the diverse instruments used (e.g. housing allowances and social housing), rent control holds an important place; OECD (2016) reports that 14 out of 20 respondent countries employ this instrument.

Our analysis relies on three key preliminary remarks. The first is that housing ownership incentive policies are most often subsidies (e.g. tax rebates and subsidized mortgage) provided to housing buyers. As such, they entail two opposite effects in terms of housing affordability. Their direct effect is to improve *consumer housing affordability* since the price net of subsidy payed buy the housing buyer is lower than in an equilibrium without subsidy. However, the subsidies allow housing suppliers to charge higher prices which deprives the *market housing affordability*. That is, despite being less expensive for the households as consumers, dwellings are actually more costly for the households as citizens since they pay the subsidy via higher taxes or debt, for instance. This is the well-known dead-weight loss due to any subsidy.<sup>2</sup> In this paper, we are interested in the market housing affordability which better captures the economic efficiency of policies. Thus, our measure of housing affordability relies on gross housing prices which is not deflated by the subsidy.

The second key remark is that housing ownership incentives often focus on certain types of dwellings to guide the housing market in the desired direction such as greenfield projects promoted by the 2012 housing subsidy program introduced in Chile (Salvi del Pero, 2016). It is common that housing ownership incentive policies target newly built dwellings and exclude second-hand housing, the objective being to promote housing construction as in the French institutional setting for example. This focus on a specific part of the market is important to our study. Indeed, the detrimental effect of ownership incentive programs on housing market affordability (ie. housing price increase) in the targeted part of the market might be offset by the reduction of the housing prices in the non-targeted part of the market. Therefore, our analysis distinguishes the overall effects from the effects on either the targeted part (new housing) or the non-targeted part (second-hand housing) of the market.

The last key remark is that unlike most existing work on housing ownership incentive policies, the present paper pay particular attention to rent control. The basic rational for this is that the response of housing investors to a policy significantly depends on the effect of this policy on the return to housing

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<sup>2</sup>In a competitive market, a consumer or producer subsidy generates a budgetary loss for the government which exceeds the total surplus gains of consumers and suppliers.

investment that is, the housing rents. It is hardly conceivable that a housing ownership incentive would have the same impact on housing prices when the rental market is free than when rents are sticky due to rent control. Additionally, rent control could play a role in distinguishing the effects of a support to rental investment which is directly affected by the rent level, from a homeownership incentive which is not.

To conduct our investigation of the effects of housing ownership incentive policies on housing affordability, we first develop a theoretical model in which owners of new housing benefit from either a homeownership incentive or a rental investment incentive. We show that both incentives reduce the second-hand housing prices and increase the new housing prices. These effects are amplified when a rent control is imposed. We empirically test these findings by exploiting a 2014 French reform in the metropolitan area of Lyon which intensified both incentives. Difference-in-difference estimate confirms the theoretical predictions. Moreover, our results suggest that the intensification of these housing ownership incentives improves the overall housing affordability and that this effect amplified by rent control.

The remainder of the paper is organized as follows. [Section 2](#) reviews the related literature in a first part and describes the theoretical model underlying our empirical analysis in a second part. [Section 3](#) describes the institutional context of the 2014 French housing reform in the metropolitan area of Lyon. [Section 4](#) discusses the identification strategy. [Section 5](#) describes the data and reports descriptive statistics. [Section 6](#) reports the regression results. [Section 7](#) concludes.

## 2 Related literature and theoretical background

Access to affordable housing is a critical issue, as showed in several papers which find evidence that housing prices increase faster than individuals' income in the United Kingdom ([Poon and Garratt, 2012](#)), Australia ([Hulse, 2007](#)) and the United States ([Stone, 2006](#)). This situation leads [Quigley and Raphael \(2004\)](#) to note that, as the ratio has been increasing steadily and has reached high levels, a small change in housing prices may have strong impact on non-housing consumption and therefore on other sector of the economy.

There are several examples of investment support policies. An example widely studied in the literature is the LIHTC ([Baum-Snow and Marion, 2009](#)). First, they show that this policy has a positive impact on the price of surrounding housing. In addition, they also show that this policy also reduces the number of high-income individuals in gentrifying neighbourhoods. Nevertheless they also show that the construction of subsidized dwellings crowds out unsubsidized construction. Regarding the french case, [Bono and Trannoy \(2013\)](#) show that the *aide à l'investissement locatif* is a policy which also promotes the construction of affordable housing through fiscal advantages. They show that

this public policy has a positive effect on the price of unbuilt land. Recently a study on the help to buy policy was conducted by [Carozzi et al. \(2019\)](#). They show that aim to free individuals from their credit and liquidity constraints had a positive impact on price. They also show that it also induced an increase in construction in area where housing was already expensive.

Public policies to support homeownership are also policies that attempt to provide affordable housing. The effect of subsidies to homeowners has been studied by [Poterba \(1984\)](#) which shows that subsidies given to homeowners usually lead to higher demand and therefore to higher prices. These empirical results are also observed in France ([Gobillon and Le Blanc, 2008](#)).

The second part of this section develops a housing market model with endogenous tenure choice in which households are both consumers and investors in the housing markets. Households choose between being renters or owner-occupants of newly built or second-hand dwellings.<sup>3</sup> A rent ceiling is imposed on the rental market of new housing but it is not necessarily binding.

We investigate the effect of two types of subsidies to housing owners whose objective is to foster access to ownership of new housing. The first consists in a housing price rebate for homeowners of new housing. It aims at capturing the effect of the interest-free loan policy in the French institutional setting ([section 3](#)). The second consists in a price rebate for owner-lessors of new housing. It aims at capturing the effect of the rental investment incentive policy described in [section 3](#).

After a presentation of the theoretical framework ([section 2.1](#)), we analyze the effects of these two policies we characterize the housing markets equilibrium in two configurations. First, we consider a free market equilibrium ([section 2.2](#)). Then, we turn to the case where a ceiling is imposed on new housing rents ([section 2.3](#)). Finally, we report the results of the simulation exercise ([section 2.4](#)).

## 2.1 Framework

We consider an economy composed of  $N$  households. Each consumes one unit of housing and chooses its residence type among the four tenures (depicted in [Figure 1](#)):

- rent a new housing ( $rn$ ) paying the rent  $R_n$ ,
- rent a second-hand housing ( $rs$ ) paying the rent  $R_s$ ,
- buy and occupy a new housing ( $on$ ) paying the imputed rent  $r_n$ ,
- buy and occupy a second-hand housing ( $os$ ) paying the imputed rent  $r_s$ .

Notice that unlike  $R_n$  and  $R_s$  which are observable rents,  $r_n$  and  $r_s$  are non-observable rents paid by homeowners to themselves. Tenures are indexed by  $i \in \mathcal{A}$  where

$$\mathcal{A} \equiv \{rn; rs; on; os\}$$

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<sup>3</sup>Since our model is not dynamic, new housing never transform into second-hand ones.

denotes the the set of tenures.

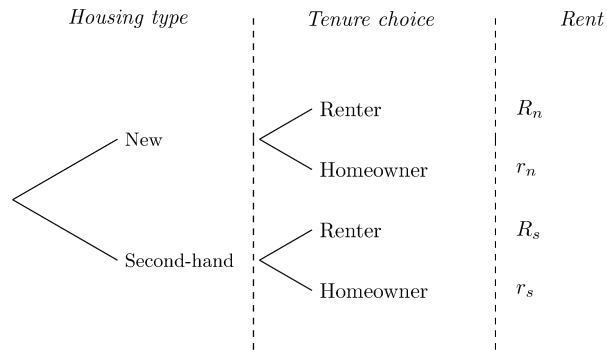


Figure 1 – Choice of a  $i$ -type residence by a household in a  $i$ -type housing,  $i \in \mathcal{A}$ .

Each tenure  $i \in \mathcal{A}$  is chosen by  $N_i$  households. The population resource constraint is:

$$\sum_{i \in \mathcal{A}} N_i = N \quad (1)$$

In addition to its residential choice, each household makes a portfolio decision depicted in Figure 2. That is, each household choosing tenure  $i \in \mathcal{A}$  allocates its exogenous wealth  $k$  between amounts of housing assets of type  $h_{i,j}$  with  $j \in \mathcal{A}$  and a non-housing asset  $a_i$ . Notice that  $\forall i \neq on, h_{i,on} = 0$  and  $\forall i \neq os, h_{i,os} = 0$ , by definition of owner-occupying housing. We have the resource constraint:

$$\sum_{j \in \mathcal{A}_i} h_{i,j} + a_i = k. \quad (2)$$

where  $\mathcal{A}_{rn} \equiv \mathcal{A}_{rs} \equiv \{rn; rs\}$ ,  $\mathcal{A}_{on} \equiv \{rn; rs; on\}$  and  $\mathcal{A}_{os} \equiv \{rn; rs; os\}$ . The costs of new and second-hand housing assets are denoted  $P_n$  and  $P_s$ . Assets are assumed to be risky as in Berkovec and Fullerton (1992). The expected return of asset  $h_{i,j}$  is the price or rent  $R_j$  paid by the housing inhabitant.<sup>4</sup> The net expected return of the non-housing risk-free asset  $a_i$  is denoted  $r_a$ . In sum, the portfolio of a household choosing tenure  $i$  as a residence is composed of:

- $h_{i,rn}$  units of new rental housing whose cost and expected return are  $(1 - \delta)P_n$  and  $R_n$ ,
- $h_{i,rs}$  units of second-hand rental housing whose cost and expected return are  $P_s$  and  $R_s$ ,
- $h_{i,on}$  units of new homeowner housing whose cost and expected return are  $(1 - \theta)P_n$  and  $r_n$
- $h_{i,os}$  units of second-hand homeowner housing whose cost and expected return are  $P_s$  and  $r_s$
- $a_i$  units of non-housing asset whose net expected return is  $r_a$ .

<sup>4</sup>In practice, the expected return should be  $R_j/(1 + \mu_{ij})$ , where  $\mu_{ij}$  is a markup which covers maintenance costs, property taxes and depreciation for example. However, for simplicity, we assume that  $\mu_{ij} = 0$ .

To encourage homeownership of new housing, the government provides a price rebate of  $\theta P_n$ ,  $\theta \in [0, 1]$  to households who buy and occupy a new housing. This price rebates aims at capturing the homeownership incentive policy. Additionally, to encourage rental investment in new housing, the government provides a price rebate  $\delta P_n$ ,  $\delta \in [0, 1]$  to owners-lessors of new housing.

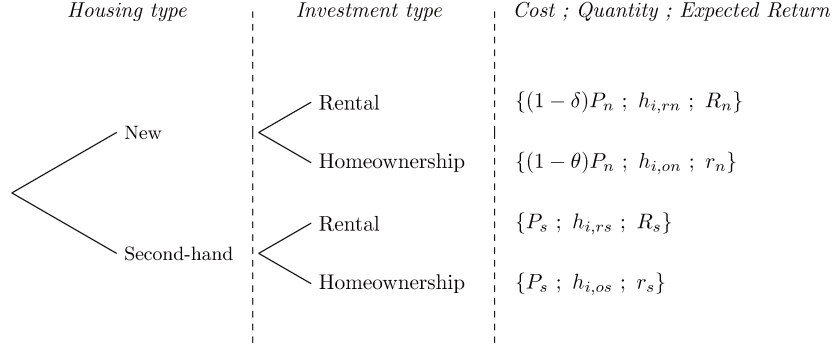


Figure 2 – Choice of  $j$ -type assets by household choosing tenure  $i$  as a residence,  $i, j \in \mathcal{A}$ .

The returns to housing assets  $h_{i,j}$  are assumed to have the same variance  $\sigma^2$  and to be stochastically independent so that their covariances are zero.<sup>5</sup> Therefore, the variance of the asset income of a household choosing tenure  $i$  as a residence is:

$$Var_i \equiv Var \left( \sum_{j \in \mathcal{A}_i} R_j h_{i,j} \right) = \sigma^2 \sum_{j \in \mathcal{A}_i} h_{i,j}^2 \quad i \in \mathcal{A}, \quad (3)$$

where the following notations have been introduced in (5):  $R_{rn} \equiv R_n$ ,  $R_{on} \equiv r_n$ ,  $R_{rs} \equiv R_s$ ,  $R_{os} \equiv r_s$ . Each household of choosing tenure  $i \in \{rn; rs; on; os\}$  consumes  $x_i$  units of private goods and one unit of housing services paying the price  $p_i$ . The  $N$  households of the economy only differ with respect to their taste for the type of housing  $i \in \mathcal{A}$ . Parameter  $\varepsilon_i$  represents this unobservable taste for tenure  $i$  of the households. Assume that the utility function of a household is additively separable with respect to  $\varepsilon_i$ . The utility of a household living in a  $i$ -type housing as:

$$U_i + \varepsilon_i \equiv x_i - \beta Var_i + \varepsilon_i, \quad (4)$$

where  $\beta$  is a risk aversion parameter (Berkovec and Fullerton, 1992). The budget constraint of a household of type  $i \in \mathcal{A}$  is:

$$x_i + R_i = y + \Gamma_i + r_a a_i \quad (5)$$

<sup>5</sup>Estimates of  $\sigma^2$  in Berkovec and Fullerton (1992) for rental and owner-occupied housing are both equal to 67. Unlike our simplifying assumption Berkovec and Fullerton estimate a covariance of 12 between these two types of housing. Including a covariance between rental housing and owner-occupied does not change our numerical results but makes the exposition of the results more complicated.

where  $y$  is the individual labor income and  $\Gamma_i$  is the individual income from land with:

$$\Gamma_i \equiv [R_n - (1 - \delta_i)P_n] h_{i,rn} + (R_s - P_s) h_{i,rs} + [r_n - (1 - \theta_i)P_n] h_{i,on} + (r_s - P_s) h_{i,os}$$

$\theta_{on} \equiv \theta$ ,  $\theta_{rn} \equiv \theta_{rs} \equiv \theta_{os} \equiv 0$ ,  $\delta_{rn} \equiv \delta$  and  $\delta_{rs} \equiv \delta_{on} \equiv \delta_{os} \equiv 0$ . For convenience, we can write:

$$\Gamma_i = \sum_{j \in \mathcal{A}_i} [R_j - (1 - \delta_j - \theta_j)P_j] h_{i,j} \quad (6)$$

where  $P_{rn} \equiv P_{on} \equiv P_n$  and  $P_{rs} \equiv P_{os} \equiv P_s$ .

## 2.2 Housing market equilibrium without rent ceiling

Using (3), (5) and (2) to eliminate  $Var_i$ ,  $x_i$  and  $a_i$  in the utility (4), we obtain for each household of type  $i \in \mathcal{A}$ :

$$U_i(h_{i,j}, j \in \mathcal{A}_i) = y - p_i + \sum_{j \in \mathcal{A}_i} [R_j - (1 - \delta_j - \theta_j)P_j] h_{i,j} + r_a \left( k - \sum_{j \in \mathcal{A}_i} h_{i,j} \right) - \beta \sigma^2 \sum_{j \in \mathcal{A}_i} h_{i,j}^2. \quad (7)$$

Differentiating with respect to  $h_{i,j}$ , the first-order condition leads to:

$$h_j \equiv h(R_j - (1 - \delta_j - \theta_j)P_j) \equiv \frac{R_j - (1 - \delta_j - \theta_j)P_j - r_a}{2\beta\sigma^2}, \quad j \in \mathcal{A}, \quad (8)$$

$h_j$  is the individual supply of housing service  $h_{ij}$ . Condition (8) indicates that this supply function only depends on the type of housing  $j$ , not on the type of tenure  $i$  consumed by the owner. Replacing  $h_j$  into the utility function (7), characterizes the indirect utility function:

$$V_i(\mathbf{p}) + \varepsilon_i \equiv U(h(R_j - (1 - \delta_j - \theta_j)P_j), j \in \mathcal{A}_i) + \varepsilon_i \quad (9)$$

where  $\mathbf{p} \equiv (R_n, R_s, r_n, r_s, P_n, P_s)$ . Assuming that  $\varepsilon_i$  are *i.i.d.* according to the following Gumbel distribution  $F(x) = P(\varepsilon_i \leq x) = e^{-e^{-(x+\gamma)}}$ , where  $\gamma$  is the Euler's constant ( $\gamma \approx 0.5772$ ), standard discrete choice theory (Anderson et al., 1992) allows to derive the number of households choosing the tenure  $i \in \mathcal{A}$ :

$$N_i(\mathbf{p}) = \frac{\exp[V_i(\mathbf{p})]}{\sum_{j \in \mathcal{A}} \exp[V_j(\mathbf{p})]} N, \quad i \in \mathcal{A}. \quad (10)$$

Recalling that each household consumes one unit of housing, the housing service market equilibrium for each type of housing  $j \in \mathcal{A}$  is characterized by:

$$S_n \equiv Nh(R_n - (1 - \delta)P_n) = N_{rn}(\mathbf{p}) \equiv D_n \quad (11)$$

$$S_s \equiv Nh(R_s - P_s) = N_{rs}(\mathbf{p}) \equiv D_s \quad (12)$$

$$(13)$$

and:

$$h(r_n - (1 - \theta)P_n) = 1 \quad (14)$$

$$h(r_s - P_s) = 1 \quad (15)$$

since each owner-occupant owns its consumed unit of housing. New and second-hand dwellings are supplied according to the supply functions  $H_n(P_n) = H_n^0 + H_n^1 P_n$  and  $H_s(P_s) = H_s^0 + H_s^1 P_s$  respectively. Therefore, equilibria on the markets of new and second-hand housing for sale require:

$$\mathbb{S}_n \equiv H_n(P_n) = N_{rn}(\mathbf{p}) + N_{on}(\mathbf{p}) \equiv \mathbb{D}_n \quad (16)$$

$$\mathbb{S}_s \equiv H_s(P_s) = N_{rs}(\mathbf{p}) + N_{os}(\mathbf{p}) \equiv \mathbb{D}_s \quad (17)$$

The six conditions (11)–(17) allow to determine the six prices  $\mathbf{p} = (R_n, R_s, r_n, r_s, P_n, P_s)$ .

### 2.3 Housing market equilibrium with rent ceiling

Now, suppose that a rent ceiling  $\widehat{R}_n$  is imposed on the rental market of new housing services. Assume that  $\widehat{R}_n$  is below the equilibrium rent  $R_n^*$  characterized in the preceding subsection. In this case, a demand excess arises in the rental market of new housing services. According to the short-side rule, the quantity is determined by the supply side of the market.

Denote  $\widehat{\mathbf{p}} \equiv (\widehat{R}_n, R_s, r_n, r_s, P_n, P_s)$  in which the new housing rent  $R_n$  is now exogenously set at the level  $\widehat{R}_n$ ; and denote  $\widehat{\mathcal{A}} \equiv \{rs; on; os\}$  which excludes  $rn$ . The equilibrium levels of  $(N_{rn}, R_s, r_n, r_s, P_n, P_s)$  are now determined by the 6-equation system:

$$Nh(\widehat{R}_n - (1 - \delta)P_n) = N_{rn} \quad (18)$$

$$Nh(R_s - P_s) = N_{rs}(\widehat{\mathbf{p}}) \quad (19)$$

$$h(r_n - (1 - \theta)P_n) = 1 \quad (20)$$

$$h(r_s - P_s) = 1 \quad (21)$$

$$H_n(P_n) = N_{rn} + N_{on}(\mathbf{p}) \quad (22)$$

$$H_s(P_s) = N_{rs}(\mathbf{p}) + N_{os}(\mathbf{p}) \quad (23)$$

where

$$N_i(\widehat{\mathbf{p}}) = \frac{\exp[V_i(\widehat{\mathbf{p}})]}{\sum_{j \in \widehat{\mathcal{A}}} \exp[V_j(\widehat{\mathbf{p}})]} (N - N_{rn}), \quad i \in \widehat{\mathcal{A}}.$$

### 2.4 Simulation exercise

This section reports the results of the simulations of the two equilibria characterized in [section 2.2](#) and [section 2.3](#). The objective is to study the effect of intensifying the homeownership incentive (i.e.



increase in  $\theta$ ) and the rental investment incentive (i.e. increase in  $\delta$ ). The parameter values chosen are reported in Table 1. The initial values of the policy parameters  $\theta$  and  $\delta$  is 10%. We consider two policy interventions: (1) an increase of  $\theta$  to 20% leaving  $\delta$  constant, and (2) an increase of  $\theta$  to 20% leaving  $\delta$  constant. The values of 10% and 20% are chosen arbitrarily but the simulation results are robust to all values of  $\theta$  and  $\delta$  in  $[0, 1]$ .

Table 1 – Parameter values.

Parameter	Definition	Value
<i>Policy parameters</i>		
$\theta$	Homeownership incentive parameter	{0.1, 0.2}
$\delta$	Rental investment incentive parameter	{0.1, 0.2}
$\hat{R}_n$	Rent ceiling in the new housing market	22.62
<i>Housing market parameters</i>		
$H_n^0$	Intercept of the new housing supply function	{0.01, 0.1}
$H_n^1$	Slope of the new housing supply function	0.09
$H_s^0$	Intercept of the second-hand housing supply function	0.5
$H_s^1$	Slope of the second-hand housing supply function	0.05
<i>Other parameters</i>		
N	Total population	1.4
$r_a$	Real return to non-housing risk-free asset	0.05
$\sigma^2$	Variance of housing assets	65
$\beta$	Risk aversion parameter	0.3
k	Household's wealth	0.1
y	Household's income	0.01

A rent ceiling in the new housing rental market  $\hat{R}_n = 22.62$  is considered. According to this rent ceiling, two types of equilibrium are alternatively considered. In the first type of equilibrium, the rent control is irrelevant since (i.e. equilibrium rent below  $\hat{R}_n$ ), while in the second type of equilibrium the rent control is relevant (i.e. equilibrium rent above  $\hat{R}_n$ ). We assume that the reason why the rent ceiling is relevant in the second case is that the supply of new housing is lower. Therefore, we consider two different level for the intercept of the new housing supply function:  $H_s^0 = 0.1$  (i.e. relevant rent control) and  $H_s^0 = 0.2$  (i.e. irrelevant rent control). In other words, the rent ceiling  $\hat{R}_n$  must be chosen below the new housing equilibrium rent with  $H_s^0 = 0.1$  and above the new housing equilibrium rent with  $H_s^0 = 0.2$ , for any  $(\theta, \delta) \in \{0.1, 0.2\}^2$ ; our results are robust to any value between these two bounds. The value  $\hat{R}_n = 22.62$  corresponds to the new housing equilibrium rent for  $H_s^0 = 0.2$  before any policy change is implemented that is, for  $\theta = \delta = 0.1$ .

The intercept and slope parameters of the housing supply functions are chosen so that the elasticity

of new (resp. second-hand) housing supply with respect to the new (resp. second-hand) housing price is included in  $[0.85, 0.98]$  (resp.  $[0.31, 0.35]$ ) whatever the configuration considered: whatever the value of  $\theta$  and  $\delta$  in  $\{0.1; 0.2\}$ , and with or without rent ceiling. These values are in line with most estimates of housing supply functions in the literature (DiPasquale, 1999).

Since the total population of *Grand Lyon* is around 1.4 millions inhabitants, we consider a population  $N = 1.4$ . The other parameter values are chosen in line with Berkovec and Fullerton (1992).

Table 2 – Simulation results.

Variable	Definition	Effect of Homeownership incentive			Effect of Rental investment incentive		
		(1)	(2)	(3)	(4)	(5)	(6)
		Free market	Rent control	(2) – (1)	Free market	Rent control	(5) – (4)
$\theta$	Homeownership incentive	10.	10.	0.	0.	0.	0.
$\delta$	Rental investment incentive	0.	0.	0.	10.	10.	0.
<i>Prices and Rents</i>							
$P_n$	Price of new housing	9.17	12.94	3.77	6.02	9.76	3.74
$P_s$	Price of second-hand housing	-16.5	-23.29	-6.79	-10.84	-17.57	-6.73
$\bar{P}$	Average housing price	-3.45	-5.21	-1.75	-2.3	-3.99	-1.68
$R_n$	Rent of new housing	-20.82	0.	20.82	-17.12	0.	17.12
$R_s$	Rent of second-hand housing	-22.22	-30.47	-8.24	-14.57	-22.95	-8.38
<i>Housing consumption</i>							
$N_{rn}$	Number of renters of new housing	-1.04	-0.42	0.63	1.44	2.21	0.77
$N_{on}$	Number of homeowners of new housing	1.87	1.58	-0.29	-0.9	-1.33	-0.43
$N_{rs}$	Number of renters of second-hand housing	-0.21	-0.26	-0.05	-0.13	-0.19	-0.06
$N_{os}$	Number of homeowners of second-hand housing	-0.62	-0.91	-0.29	-0.41	-0.69	-0.28
$N_{rn} + n_{on}$	Number of consumers of new housing	0.83	1.16	0.34	0.54	0.88	0.34
$N_{rs} + N_{os}$	Number of consumers of secon-hand housing	-0.83	-1.16	-0.34	-0.54	-0.88	-0.34

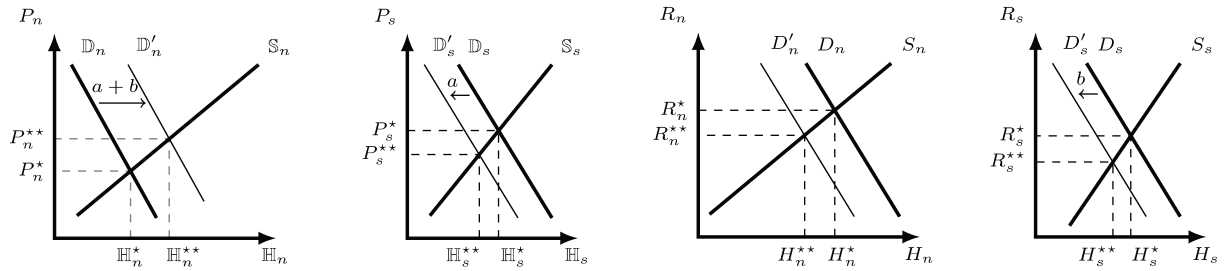
*Notes: For readability, all cells have been multiplied by 100. For instance, when the rent ceiling is irrelevant (free market), increasing the homeownership incentive  $\theta$  by 0.1 units increases the price of new housing by 0.09 units. The average housing price is computed as follows:  $\bar{P} = [(n_{rn} + n_{on})P_n + (n_{rs} + n_{os})P_s]/N$ . The individual supplies of housing of type  $j \in \{on; os; rn; rs\}$  are  $h_{on} = h_{os} = 1$ ,  $h_{rn} = N_{rn}/N$  and  $h_{rs} = N_{rs}/N$ .*

Table 2 reports the results of the simulations and provides several important insights.<sup>6</sup> First, let us consider the effect of an intensification of the homeownership incentive both when the rent control is irrelevant (column 1) and when it is relevant (column 2). We observe that an increase in  $\theta$  exerts

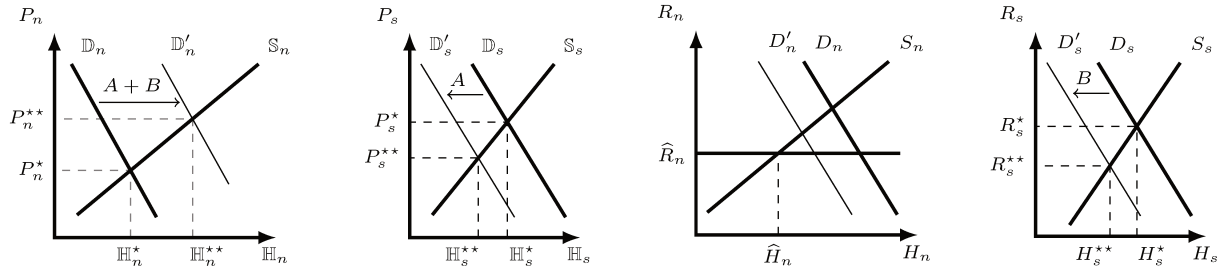
<sup>6</sup>Appendix A reports the raw data from which the differences in Table 2 are calculated.

an upward pressure on the new housing price and a downward pressure on the second-hand housing price.

As depicted in Figure 3, these effects are due to a shift in demand from the second-hand housing market towards the new housing market. Attracted by the subsidy, homeowners and renters of second-hand housing become homeowners of new housing. This can be seen in columns 1 and 2 of Table 2 in which  $n_{on}$  increases while  $n_{os}$  and  $n_{rs}$  decrease. This explains the increase in the demand for new housing  $n_{rn} + n_{on}$  and thus the increase in the price  $P_n$ . Notice that some renters of new housing also become homeowners of their housing. This composition change has a negligible effect on  $P_n$  since it does not affect the demand size. The decrease in the price of second-hand housing  $P_s$  is explained by the cut in the demand of owner-occupied dwellings in the second-hand market.



(a) New housing for sale (no rent control) (b) Second-hand housing for sale (no rent control) (c) New rental housing (no rent control) (d) Second-hand rental housing (no rent control)



(e) New housing for sale (rent control) (f) Second-hand housing for sale (rent control) (g) New rental housing (rent control) (h) Second-hand rental housing (rent control)

Figure 3 – Effects of intensifying the homeownership incentive.

According to column 5 and 6 of Table 2, the rental investment incentive has the same qualitative effect on the new and second-hand housing prices as the homeownership incentive. An increase in  $\delta$  increases the new housing prices and decreases the second-hand housing prices.

As depicted in Figure 4, the channel is different from the case of the homeownership incentive. The effect is now driven by the increase in the individual supply of new rental housing  $h_{rn}$  spurred by

the rise in  $\delta$  (Figures 4c and 4g). These new investors directly increase the demand for new housing (Figure 4a) and attracts households from the second-hand rental and sale markets (decrease in  $n_{rs}$  and  $n_{os}$ ). This shift in demand explains that the price  $P_n$  increases in the new housing market and that the price  $P_s$  decreases in the second-hand market.<sup>7</sup>

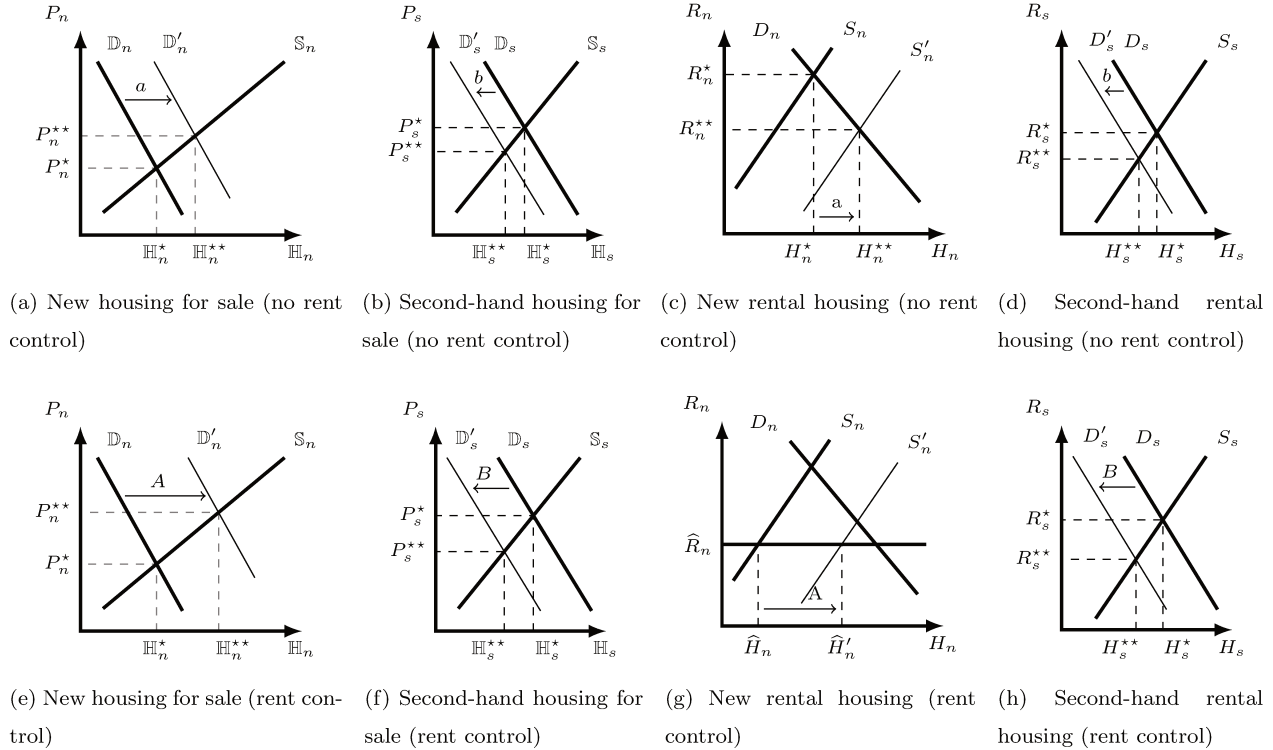


Figure 4 – Effects of intensifying the rental investment incentive.

These results are summarized in:

**Result 1** *In the presence and in the absence of rent ceiling, the homeownership and rental investment incentives have the same qualitative impact on housing prices. They both increase new housing prices and decrease second-hand housing prices.*

Result 1 indicates that both housing ownership incentives have an ambiguous effect on housing affordability that is, on the average housing price. It decreases if the decrease in the second-hand housing price overcomes the increase in the new housing price; it increases otherwise. Which effect overcomes the other is an empirical issue investigated in the following sections. In Table 2,  $\bar{P}$  decreases. This

<sup>7</sup>Notice that a left shift in the demand curve should have been represented in Figures 4c and 4g. For the clarity of the graphical representation, this superfluous change is ignored.

decrease is due to two main causes. First, the elasticity of the supply of second-hand housing with respect to the price is low compared to that of new housing. Second, the number of households in the second-hand market is high compared to the those in the new housing market. This result can be summarized in:

**Result 2** *If the elasticity of the supply of second-hand housing with respect to the price is sufficiently low and if the number of households in the second-hand market is sufficiently large, then the housing ownership incentives entail a cut in the average housing price.*

Let us now consider how the effects of housing ownership incentives on housing prices, stated in [Result 1](#) and [Result 2](#), are affected by the presence of a relevant rent control. Columns 3 and 6 indicate that a rent ceiling amplifies both the increase in the new housing price and the decrease in the second-hand housing price. This can be summarized in:

**Result 3** *A rent ceiling increases the effect of the homeownership and the rental investment incentives both on new housing prices (ie. faster increase in  $P_n$ ) and on second-hand housing prices (ie. faster decrease in  $P_s$ ).*

And a result analogous to [Result 2](#) follows:

**Result 4** *If the elasticity of the supply of second-hand housing with respect to the price is sufficiently low and if the number of households in the second-hand market is sufficiently large, then rent control amplifies the cut in the average housing price entailed by the housing ownership incentives.*

First, consider the case of the homeownership incentive. The intuition behind [Result 3](#) can be understood from [Figures 3e to 3h](#). Rent control imposes rationing on the new housing rental market so that more households would like to rent a new dwelling they but cannot since the supply is insufficient ([Figure 3g](#)). Therefore, the homeownership incentive attracts many households from the second-hand market who are not crowded-out by renters of new housing who by their own dwelling. Thus, there is a significant increase in the demand of new housing for sale and an important increase in their price  $P_n$ . This can be seen in column 3 of [Table 2](#) which indicates that much more renters of new housing remain in their dwelling in the presence of a rent control compared to the free-market case.<sup>8</sup> The fact that renters of new housing do not become homeowners also explains that rent control increases the number of homeowners from the second-hand market turning to the new housing market. This explains the deeper cut in the second-hand housing price  $P_s$ .

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<sup>8</sup>The reason why some renters still buy their new housing is that it becomes too costly for landlords to rent these housing (increase in  $P_n$ ) so that they sell them to their tenants. This effect would be represented by a left shift of  $S_n$  in [Figure 3g](#). For expositional concerns, we do not represent this peripheral effect.

Second, let us now turn to the case of the rental investment incentive. The intuition is, again, a slightly different. It can be understood from [Figures 4e to 4h](#). Specifically, comparing [Figure 4g](#) to [Figure 4c](#) show that rent control spurs investors to buy larger amounts of new housing because they do not suffer a decrease in the return to their return (i.e. the rent  $\widehat{R}_n$  is fixed). This explains the stronger increase in the demand for new housing for sale ([Figure 4e](#) compared to [Figure 4a](#)) and the larger decrease in second-hand housing for sale ([Figure 4f](#) compared to [Figure 4b](#)). This allows to understand why rent control increases the effect of rental investment incentives on housing prices.

The purpose of the remainder of the paper is to test empirically the theoretical predictions stated in [Results 1 to 4](#).

### 3 Institutional setting

The Pinel Act is part of a long-standing public policy aiming at promoting the construction of new housing by encouraging private agents to buy new housing. The construction of new housing is a major issue in France because the housing shortage contributes to a substantial increase in housing prices: the price of new dwellings increases by 90% between 2000 and 2007 while the growth rate of household income is of 20% in the meantime. The Besson program in 1999, the Robien program in 2003 then the Scellier Act in 2008 have contributed to create the public policy framework that was in place at the time of the Pinel reform. This public policy has two main components : the interest-free loan policy (abbreviated PTZ) and the support to rental investment.

The interest-free loan policy is implemented to help individuals to become homeowners ([Gobillon and Le Blanc, 2008](#)). Eligible individuals do not pay interest on 40% of the new dwelling price, up to a certain threshold. However, to benefit from the PTZ instrument, individuals must respect certain conditions. First, the dwelling must be new; it is not possible to benefit from the PTZ to buy on the second-hand market.<sup>9</sup> Individuals cannot benefit from the PTZ if they have been owners in the previous two years and they must not earn income above certain income thresholds. Finally, they must own the dwelling for a minimum period of time.

The support to rental investment is related to the rental market. This instrument allows landlords to obtain tax deductions if they rent their dwellings to a low or moderate-income household. Much like the PTZ, there are several conditions that a landlord must respect to benefit from the tax deduction. Like for the PTZ, the dwelling that the landlord has purchased to rent must be new. In addition, to benefit from the tax deduction, landlords must rent their dwelling to individuals with moderate incomes and at a moderate rent. Finally, the landlord must also rent the dwelling for a determined

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<sup>9</sup>There are exceptions to this rule. An individual can benefit from the PTZ instrument if a dwelling bought on the second-hand market is damaged and requires major renovations.

period of time that is, 6, 9 or 12 years, before deciding to sell it. The longer they put their dwelling on the rental market, the higher the tax deduction.

In order to target the policy in areas where the housing shortage is the most severe, the municipalities of the French territory have been divided into three zones: zone A for municipalities where the real estate market is the most tight, zone B for the intermediate markets and zone C for the less tight real estate markets.<sup>10</sup> The zone in which the housing is located determines the conditions under which these instruments can be accessed: the tighter the housing market, the less restrictive the conditions. The Pinel reform mainly consisted in updating the zoning according to the evolution of the housing market. Some zones in the agglomeration of large cities such as Lyon, Marseille, Lille and Montpellier have been upgraded from B to A and some zones in less dynamics areas have been downgraded from B to C.

The PTZ instrument is affected by the municipality zone ranking in two ways. First, the income ceiling that individuals must respect in order to benefit from the PTZ varies according to the level of the zone: the higher the grade, the higher the income ceiling. For example, in 2015, the income threshold was 36,000 euros for a single person in zone A but 26,000 euros in zone B. Second, the maximum price of the housing on which the zero rate loan applies is higher when the grade is high: 150,000 euros for a single person in zone A against 135,000 euros in zone B.

The eligibility for the support to rental investment is also affected in two ways by the change in the rank of the zone. On the one hand, the rent ceiling increases from 10 euros per square meter in zone B to 11.9 euros in zone A. On the other hand, the maximum eligible income of the tenant increases: for a single person, the income ceiling of the tenant goes from 31,000 euros in zone B to about 38,000 euros in zone A.

By evaluating the effect on housing prices of a switch from zone B to zone A, we assess the effect of the extension of the two instruments that support the purchase of new housing.<sup>11</sup> We have chosen to concentrate our evaluation on the Lyon metropolitan area. Among the four metropolitan areas concerned by an upward zoning change, the Lyon conurbation has the advantage of being composed of a central city and a number of smaller cities around it. Since the zones are defined at the municipality level, this ensures that there is sufficient variations in the evolution of zoning. Lyon and another neighbouring city (Villeurbanne) were classified as A before 2015 while most of the other surrounding cities were classified as B before 2015 and have been reclassified as A.

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<sup>10</sup>Zones A and B are subdivided in respectively zones A bis/A and B1/B2. For simplicity, we will call a change from B1 to A a change from B to A.

<sup>11</sup>The change affected also other programs of smaller importance on 1<sup>st</sup> January 2015.

## 4 Empirical strategy

In order to assess the effect of the policy, we use a difference-in-difference (DiD) approach. We compare the growth rate of prices in the treated area A to the growth rate of prices in zone B after the reform. We want to estimate the effect of the policy on the price  $Y_{ijt}$  of housing sale  $i$  in district (called IRIS)  $j$  at date  $t$ .  $T_t$  is a binary variable taking the value 1 if the sale occurred after the 1<sup>st</sup> October 2014, and 0 otherwise.  $D_{ij}$  is also a binary variable that takes the value 1 if the sale occurred in zone A and 0 if the sale occurred in zone B. The baseline DiD model that we fit is of the form:

$$Y_{ijt} = \beta_T T_t + \beta_D D_{ij} + \beta_{TD} T_t D_{ij} + \eta' \mathbf{X}_{ijt} + \zeta G_{ijt} + \mu_{ij} + \epsilon_{ijt} \quad (24)$$

The coefficient  $\beta_T$  is the mean difference in price between sales that occurred before and after the reform for non-treated housing. The coefficient  $\beta_D$  is the mean difference in prices between sales in zone A and those in zone B before the reform. Our coefficient of interest is  $\beta_{TD}$  which estimates the effect of the policy on the selling price that is, the difference in the variation of prices that occurred after the reform in zone B compared to zone A.

$\mathbf{X}_{ijt}$  is a vector of hedonic characteristics of the housing unit. The number of rooms is computed as a categorical variable to capture non linearity, such as the floor level and the energy label. The other control variables are the dummy variables that capture the presence of a dedicated parking space and the presence of more than one bathroom. The only continuous control variable is the average space per room.

$G_{ijt}$  is a locational characteristics which is interacted with the transaction date. The locational characteristic is the distance to the city center of Lyon interacted with the orientation of the housing unit with respect to the city center of Lyon (North, South, East or West). These terms are intended to control for changes in the spatial structure of the city, such as gentrification dynamics, that may induce difference in price variation between the treated and control group. Note that these characteristics are time invariant, which avoids problems of reverse causality.

Specification (24) allows to estimate the average effect of the treatment over the two post-treatment years, i.e. 2015 and 2016. In order to examine more precisely the variation of this effect over the two years we estimate a more flexible specification:

$$Y_{ijt} = \sum_{\substack{a=-2 \\ a \neq 0}}^9 \beta_T^a T_{t+a} + \beta_D D_{ij} + \sum_{\substack{a=-2 \\ a \neq 0}}^9 \beta_{TD}^a T_{t+a} D_{ij} + \eta' \mathbf{X}_{ijt} + \zeta G_{ijt} + \mu_{ij} + \epsilon_{ijt} \quad (25)$$

where the dummy variable  $T_{t+a}$  indicates the quarter  $t+a$ .

As described in [section 3](#), an important condition to benefit from the support to rental investment is to rent the housing below a threshold that varies with the zone. We consider as constrained ( $C_j=1$ )



the districts where the rent level of the district in 2014 was above the rental threshold imposed by the law to benefit from the rental market subsidy before the zone change.

$$\begin{aligned}
 Y_{ijt} = & \beta_T T_t + \gamma D_{ij} + \beta_C C_j + \beta_{CT} C_j T_t + \beta_{CD} C_j D_{ij} + \beta_{DT} D_{ij} T_t \\
 & + \beta_{TDC} T_t D_{ij} C_j + \eta' \mathbf{X}_{ijt} + \zeta G_{ijt} + \mu_{ij} + \epsilon_{ijt}
 \end{aligned} \tag{26}$$

The coefficient  $\beta_{TDC}$  of the interaction term  $T_t D_{ij} C_j$  allows us to test whether the rent control amplifies or mitigates the effect of the housing ownership incentives. Similarly to (25), we also estimate the more flexible specification:

$$\begin{aligned}
 Y_{ijt} = & \sum_{\substack{a=-2 \\ a \neq 0}}^9 \beta_T^a T_{t+a} + \beta_D D_{ij} + \beta_C C_j + \beta_{CT} \sum_{\substack{a=-2 \\ a \neq 0}}^9 C_j T_{t+a} + \beta_{CD} C_j D_{ij} + \beta_{DT} \sum_{\substack{a=-2 \\ a \neq 0}}^9 D_{ij} T_{t+a} \\
 & + \sum_{\substack{a=-2 \\ a \neq 0}}^9 \beta_{TDC}^a T_{t+a} D_{ij} C_j + \eta' \mathbf{X}_{ijt} + \zeta G_{ijt} + \mu_{ij} + \epsilon_{ijt}
 \end{aligned} \tag{27}$$

## 5 Data and summary statistics

### 5.1 Data

Our data covers real estate transactions that took place in the Grand Lyon area between 2014 and 2016. The PERVAL database is constructed by notaries who are in charge to keep track of every housing sale that occurred and record a large panel of information about each sale. Most of the sales made in the Grand Lyon during this period are recorded.<sup>12</sup> However, the database is not exhaustive since it is an initiative of the national notary association which does not constitute a legal obligation for notaries.

The information describing the dwellings includes key features such as the number of rooms or the living surface. In addition, information on floor level, date of construction and energy label are included. It also includes information on specific rooms or services provided with the dwelling, such as the presence of a privatized parking place. The time and place of sale are also recorded. The precise day of each sale and the location with the spatial coordinates are recorded for each sale.

### 5.2 Summary statistics

The sample consists of 5,729 new housing transactions and 24,617 second-hand housing transactions as reported in Table 3. The second-hand dwelling sales are more numerous because second-hand housing

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<sup>12</sup>Among approximately twelve thousand sales recorded yearly, the Grand Lyon administration estimates that at least 80% of all sales are recorded.

stands for the majority of total housing stock.

Table 3 – Contingency table of the number of dwellings in the Grand Lyon area, 2014-2016

	New housings	Second hand housings	Total
Treated	568	3,181	3,749
Not treated	5,161	21,436	26,597
Constrained	3,342	17,325	20,667
Unconstrained	2,877	7,782	10,169
Total	5,729	24,617	30,346

Descriptive statistics are displayed in [Table 4](#) which reports the mean value of each variable in the database for the entire subsample in column 1. In Addition, second-hand and new dwellings are displayed in column 2 and 3. In the first column we can see that the average price for a dwelling is 213 294 euros. The price of second-hand dwellings is slightly higher whereas the price of new dwellings is lower. These figures are in line with the statistics about the dwelling size. Because second hand dwellings are in average bigger than new dwellings. Second hand dwellings are more spacious and have more rooms in average than new dwellings. Overall, 74,1% of the dwellings sold during the 2013 to 2015 period in the Greater Lyon area have 2, 3 or 4 rooms. Most of the dwellings sold in the Greater Lyon are apartments, 84,8% of second hand dwellings and 95,3% of new dwellings are apartments. Houses are the minority. Most of the dwellings have only one bathroom and 63,9% of the dwellings have a parking place. On average they are more new dwellings with at least one parking place in comparison to second hand dwellings. Dwellings with grades higher than D<sup>13</sup> are not common in the Greater Lyon area as they represent in average 13,3% of all dwellings.

[Figure 5a](#) presents the geographical location of the treated and control areas. The map shows that the treated areas are concentrated in the center of the Lyon conurbation while the control areas are located on the periphery of Lyon. However, [Figure 5b](#) suggests that treated zones are not correlated with high prices areas which lets us expect a low selection bias.

## 6 Results

The first interesting results focus on the price of new dwellings in which the households benefit from subsidies. Our theoretical model shows that the new housing market should experience a price increase

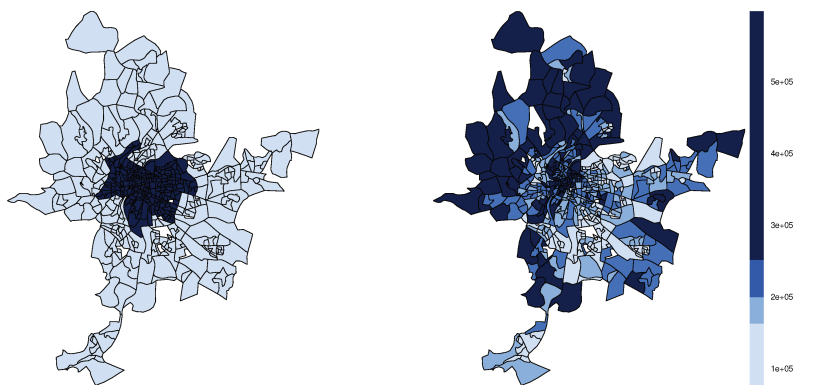
<sup>13</sup>The EU energy label is a grading system that assesses the energy performance of a dwelling. A is the best whereas G is the worst.

Table 4 – Descriptive statistics of housing sales

	(1)	(2)	(3)
	All housings	Second hand housings	New housings
Price in euro	213,294.800	217,969.300	193,208.900
Average surface of dwellings	72.842	75.920	59.617
Average number of rooms	3.250	3.364	2.762
Number of dwellings with more than one bathroom	11,7%	12,3%	9,3%
Number of dwellings with at least one parking place	63,9%	58,1%	88,9%
Share of dwellings of 2, 3 or 4 rooms	74,1%	71,5%	85,4%
Share of appartements	86,8%	84,8%	95,3%
Share of new dwellings	18,9%	00,0%	100,0%
Share of dwellings with EU grade higher than D*	13,3%	13,9%	10,6%
Share of sales that occurred in treated area	12,4%	12,9%	9,9%
Share of sales that occurred after the policy	75,2%	73,6%	81,7%
Share of sales that are treated by the policy	9,4%	9,7%	8,2%
Number of dwellings	30 346	24 617	5 729

Descriptives statistics of all sales that are recorded in the PERVAL database in the Greater Lyon area during the period of 2013 up to 2015. They cover the 59 municipalities of the Greater Lyon area.

\*The EU energy label is a grading system that assesses the energy performance of a dwelling. A is the best grade whereas G is the worst.



(a) Map of treated (dark blue) zones by the reform after 2015. (b) Average prices per district, 2013 to 2014.

Figure 5 – Maps of prices and treated areas.

after the policy is implemented, We empirically test this prediction by estimating equation (24). Results are presented in columns (1) and (2) of Table 5.

Table 5 – Effect of the policy on housing prices

	<i>Dependent variable: log of housing prices</i>					
	New		Second-hand		All	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>D</i>	0.030 (0.024)	-0.101* (0.054)	-0.061*** (0.011)	-0.076** (0.036)	-0.035*** (0.010)	-0.064** (0.029)
<i>T</i>	-0.033* (0.018)	-0.562 (0.419)	-0.025** (0.012)	-0.179** (0.078)	-0.037*** (0.013)	-0.224*** (0.083)
<i>D</i> × <i>T</i>	-0.002 (0.027)	0.120*** (0.045)	-0.015 (0.010)	-0.011 (0.024)	-0.009 (0.011)	-0.008 (0.028)
Hedonic controls	YES	YES	YES	YES	YES	YES
Year and month fixed effects	YES	YES	YES	YES	YES	YES
district fixed effects	YES	YES	YES	YES	YES	YES
Time varying-effects	NO	YES	NO	YES	NO	YES
Observations	5,729	5,729	24,617	24,617	30,346	30,346
R <sup>2</sup>	0.811	0.866	0.796	0.816	0.777	0.798
Adjusted R <sup>2</sup>	0.799	0.828	0.791	0.802	0.773	0.786

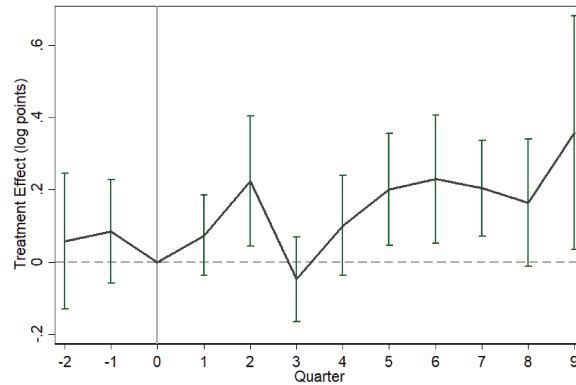
*Notes: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. The statistical individuals are new individual sales. Dependent variable is log of housing prices. Hedonic characteristics are: number of room as a categorical variable, presence of a dedicated parking space, presence of more than one bathroom, average space per room. Time-varying controls are interaction effects of year and month effects with distance to the inner city of Lyon and the localisation of the transaction (East/West/South/North) with respect to the inner city of Lyon. The treatment variable *D* takes the value 1 if the sale occurred in the A zone and 0 otherwise (zone B). The dummy *T* takes the value 1 if the sale occurred after the 1<sup>st</sup> of October of 2014 and 0 otherwise. Standard errors are clustered at the district level.*

We only present the coefficients of primary interest: the treatment variable *D* indicating dwellings in zone A (stronger incentive to housing owners), the time variable *T* which indicates sales occurring after the 1<sup>st</sup> October 2014 and the key interaction term *D* × *T* that is, the difference in the average variation in sale prices between the treatment and control group.

We note that taking account of different price dynamics between areas by interacting time with distance and position relatively to the center influences the results. This is expected as treated areas are mainly concentrated around the center of Lyon and are in consequence likely to be affected by different price dynamics than untreated areas.

All controls included we find a positive and significant effect of the reform on the prices of new sales: the average effect of the reform in 2015 and 2016 on sale prices of new housings is 12%. These

Figure 6 – Effect on new housing prices



Notes: error bars indicate confidence intervals at the 95% level. Figure illustrates the treatment effect as defined in Equation (25). The parametric equivalent is in Table 5, column (2).

results are indeed of the expected sign and confirm our model conclusions about the effect of the policy the price of new housings.

The 12% estimate is an average effect of the policy over the two years, but it is likely that the effect of the policy is not homogenous during this period. To investigate more specific variations, we study the effect of the policy on quarterly price changes. This also allows to test the pre-trend assumption. To this purpose, we regress equation (25) with the same control variables than in column (4) of Table 5. The results are graphically represented in Figure 6.

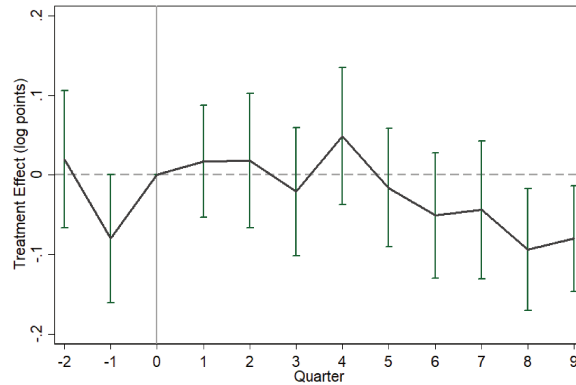
First, we do not observe any significant differences in the variation of prices in the two quarters preceding the reform. Second, the positive effect of the reform starts to be significant one year after the reform. Finally, about two and a half years after the reform, the price increased by 35% in the treated areas compared to the control areas.

Let us now turn to the second-hand market in which the theoretical model predicts that the policy decreases the old housing market price. The results are reported in columns (3) and (4) of Table 5. Regarding the interaction term  $D \times T$ , our results also tend to be quite robust in every specifications, the average effect of the reform on 2015-2016 is negative and insignificant. As in the new housing case, we present the results of the more flexible specification (25) in Figure 7.

Pre-treatment variations again tend to support the common-trend assumption. We see that prices seem to decrease in the treatment group compared to the control group from one year after the reform, but that the decrease is only significant eight and nine quarters after the beginning. The effect of the policy at the end of the observation period is an 8% decrease in the prices of second-hand buildings.

These results tend to confirm the theoretical predictions. As the demand increase in the new

Figure 7 – Effect on second-hand housing prices



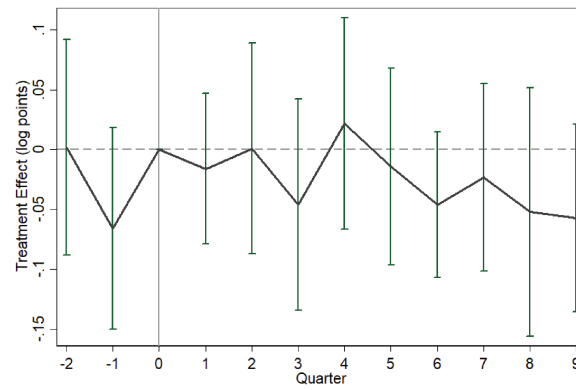
Notes: error bars indicate confidence intervals at the 95% level. The figure illustrates the treatment effect as defined in Equation (25). The parametric equivalent is in Table 5, column (4).

housing market, demand in other market could either remain constant or decrease. This negative sign seems to imply that the demand in the second-hand housing indeed diminished after the policy is implemented in the treated area.

The housing market is mainly made of second-hand transactions. In consequence, the aggregate effect is mainly driven by the effect on this sub-market. This is what explains the non significant effect of the program on the whole housing market that can be found in column (6) of Table 5 and in the Figure 8.

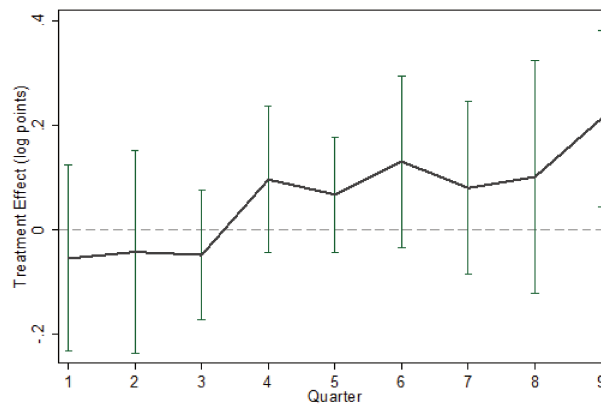
Finally, Table 6 present estimate results of regression specification (26) which differentiates between housing in district with constraining rent control and housing in district not constrained. As shown by our theoretical model, we can expect that rent control amplifies the effect of the policy which seems to be supported by the results in the first column for new housing. This is confirmed by Figure 9 which reports the results of the more flexible regression (27). The results for the second-hand market is less conclusive and calls for further investigation.

Figure 8 – Effect on housing prices



Notes: error bars indicate confidence intervals at the 95% level. The figure illustrates the treatment effect as defined in Equation (25). The parametric equivalent is in Table 5, column (6).

Figure 9 – Effect on new housing prices



Notes: error bars indicate confidence intervals at the 95% level. The figure illustrates the treatment effect as defined in Equation (27).

Table 6 – Regression of new housing prices during the period 2014-2016 in the Grand Lyon metropolitan area with differentiation between both instruments.

	<i>Dependent variable: log of individual sale prices</i>		
	New	Second-hand	All
Tr	−0.400*** (0.050)	−0.107*** (0.041)	−0.082** (0.041)
Ap	0.081 (0.164)	0.051 (0.087)	0.051 (0.087)
cons	0.020 (0.018)	0.062*** (0.011)	0.055*** (0.011)
Tr:Ap	0.009 (0.015)	−0.075*** (0.028)	−0.034 (0.023)
Tr:cons	−0.016 (0.030)	0.016 (0.016)	0.026* (0.014)
Ap:cons	−0.003 (0.018)	−0.022** (0.011)	−0.024*** (0.009)
Tr:Ap:cons	0.042 (0.040)	0.029** (0.013)	0.016 (0.012)
Hedonic controls	YES	YES	YES
Year and month fixed effects	YES	YES	YES
district fixed effects	YES	YES	YES
Time varying-effects	YES	YES	YES
Observations	5,729	24,617	30,346
R <sup>2</sup>	0.807	0.778	0.756
Adjusted R <sup>2</sup>	0.783	0.772	0.750

*Notes: \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . The statistical individuals are new individual sales. Dependent variable is log of housing prices. Hedonic characteristics are: number of room as a categorical variable, presence of a dedicated parking space, presence of more than one bathroom, average space per room. Time-varying controls are interaction effects of year and month effects with distance to the inner city of Lyon and the localisation of the transaction (East/West/South/North) with respect to the inner city of Lyon. The treatment variable  $D$  takes the value 1 if the sale occurred in the A zone and 0 otherwise (zone B). The dummy  $T$  takes the value 1 if the sale occurred after the 1<sup>st</sup> of October of 2014 and 0 otherwise.  $C$  takes the value 1 if the rent level of the district in 2014 was above the rental threshold imposed by the law to benefit from the rental market subsidy in 2014, and take the value 0 if the rent level in 2014 was below the rental threshold imposed by the law in 2015. Standard errors are clustered at the district level.*



## 7 Conclusion

In this paper we evaluate the effect of two housing ownership incentive, namely a interest-free loan policy and a tax deduction to landlord policy. We show that the policy increased housing price on the new housing market, while the price of second-hand housing decreased. Furthermore, the overall impact of the policy on housing price was negative. These results suggest that the policy successfully increased the access to housing ownership for new dwellings and promoted the provision of affordable housing in the urban area.

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# Appendices

## A Raw data for the simulation

Variable	Definition	Free market	Free market	Free market	Rent ceiling	Rent ceiling	Rent ceiling
$\theta$	Homeownership incentive	0.1	0.2	0.1	0.1	0.2	0.1
$\delta$	Rental investment incentive	0.1	0.1	0.2	0.1	0.1	0.2
$P_n$	Price of new housing	6.20901	6.30069	6.26923	6.94023	7.06962	7.03785
$P_s$	Price of second-hand housing	4.82378	4.65876	4.71538	5.30759	5.07468	5.13187
$\bar{P}$	Average housing price	5.47564	5.44109	5.45261	6.04766	5.99558	6.00781
$R_n$	Rent of new housing	22.6207	22.4125	22.4496	22.6207	22.6207	22.6207
$R_s$	Rent of second-hand housing	22.579	22.3568	22.4334	23.2169	22.9122	22.9874
$n_{rn}$	Number of renters of new housing	0.609632	0.599196	0.624047	0.586008	0.581828	0.608118
$n_{on}$	Number of homeowners of new housing	0.049179	0.0678664	0.0401839	0.0486125	0.0644382	0.0352882
$n_{rs}$	Number of renters of second-hand housing	0.635574	0.63352	0.634235	0.641104	0.638528	0.639174
$n_{os}$	Number of homeowners of second-hand housing	0.105615	0.0994183	0.101534	0.124276	0.115206	0.117419
$n_{rn} + n_{on}$	Number of consumers of new housing	0.658811	0.667062	0.664231	0.634621	0.646266	0.643407
$n_{rs} + n_{os}$	Number of consumers of second-hand housing	0.741189	0.732938	0.735769	0.765379	0.753734	0.756593
$h_{rn}$	Individual supply of new rental housing	0.435452	0.427997	0.445748	0.418577	0.415591	0.43437
$h_{rs}$	Individual supply of second-hand rental housing	0.453981	0.452514	0.453025	0.457931	0.456091	0.456553

## B Share of new dwellings

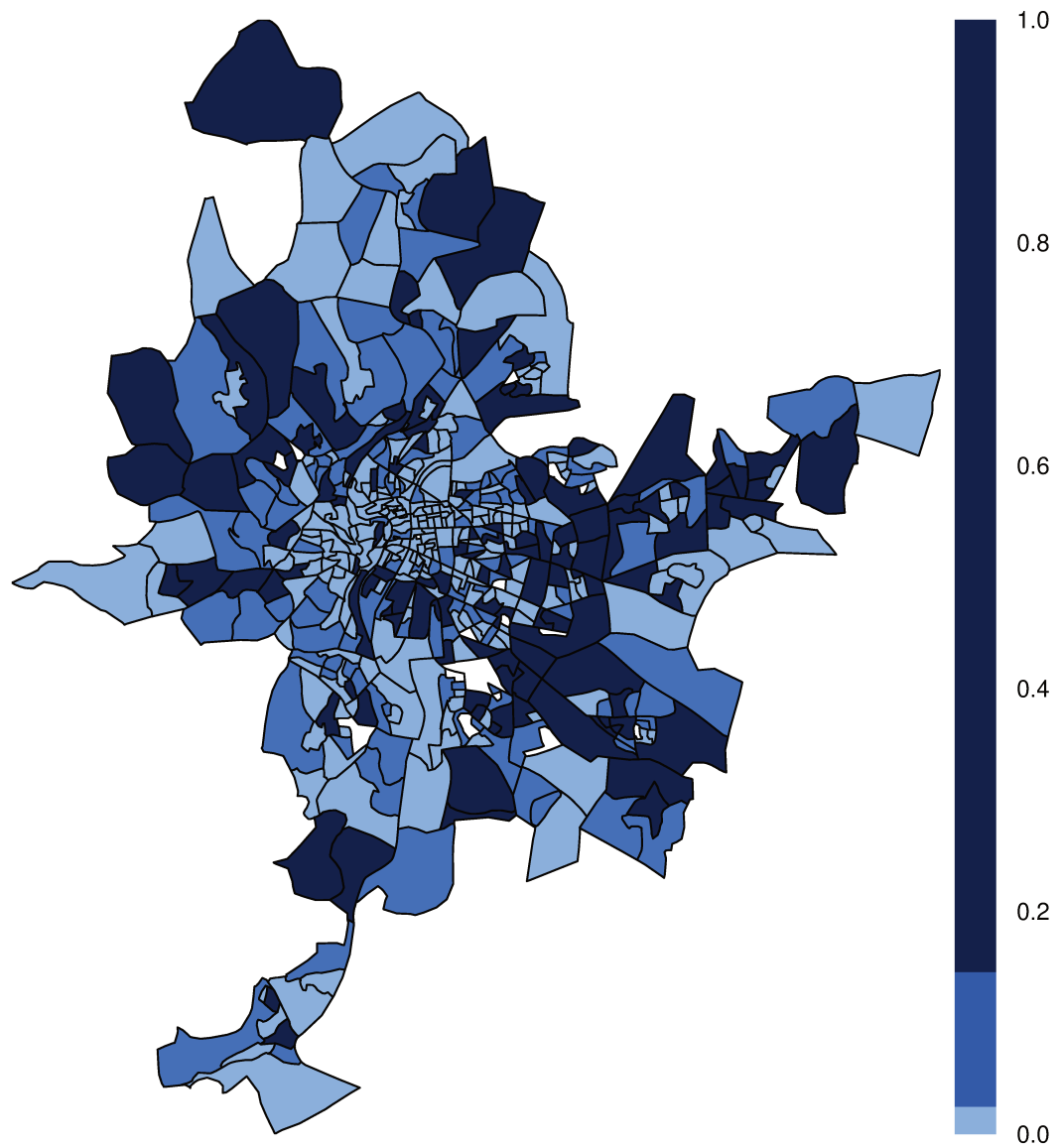


Figure 10 – Map of the share of new dwellings by IRIS in the Greater Lyon area during the 2013 to 2015 period

# Conclusion

In order to conclude this thesis, we propose to review the main contributions made in these chapters. Then we will expose the main limitations of these results and finally we will discuss the public policy implications.

## 1 Brief summary of the findings and contributions

In the first chapter we have tried to understand what explains rent to price ratios spatial heterogeneity. Through our analysis we have been able to show that this divergence in the rent to price ratio also exists in the Lyon area. Then, in a second step, we put forward several theoretical explanations that could justify the existence of these discrepancies. Finally, we tried to empirically test the validity of our hypotheses formulated using theoretical work.

Our contribution lies in the explanation of the variables that make it possible to explain the divergences in the rent to price ratio. We also present empirical evidences that are in line with the theoretical results.

In the second chapter we tried to highlight the local impact of social housing construction on housing prices. We have used two methods in this chapter. Each of the two methods uses a particularity of the SRU law and is tested on two significantly different samples. One sample is more composed of large municipalities while the other focuses on small ones.

In this chapter our contribution lies in the evaluation of the effect of social housing construction. Our interesting contribution is to show that the negative effect of social housing construction on housing prices is found in both large and small municipalities.

In the third chapter we tried to assess the impact of public policies that facilitate access to credit and help landlords. To do this, we use the PINEL reform, which makes it easier to access these two mechanisms and increases the rent ceiling for low-cost housing. In a first theoretical part we highlight the positive impact on prices of these two policies. In addition, the model also shows that if both policies appear to have a positive effect on new housing prices, and a negative effect on old housing prices, when the two policies are combined an ambiguous effect appears in the old housing market.

Our analysis shows that it is the effect of the relaxation of the rent ceiling that mitigates the negative effect observed in the old housing market.

This is where the contribution of this chapter lies. We have highlighted the cross effect of two policies promoting the production of affordable housing, as well as the effect of the relaxation of the rent cap on private housing prices. Effect that is exposed in an explicit theoretical contribution.

## 2 Limitations and possible improvements

In chapter 1 we highlighted several factors that explain the divergence between rent to price ratios inside an agglomeration. Nevertheless, if in our empirical analysis we are able to show explicitly how each variable impact the determination of rent to price ratio, in the empirical analysis this is less the case. Our empirical work does not allow us to correct the possible endogeneity bias. If future research were able to correct this problem, it would be a significant improvement compared to the results presented here. In addition, we only have data on the rental housing market for one year, 2014. Obtaining data over a longer period of time could improve the accuracy of the simulations we implemented to compute simulated rents and prices. Finally, another important limitation concerns the calculation of rent to price ratios. Recalculating the price or rent of a dwelling is not enough to insure comparability. Indeed, it is possible that the dwellings put up for sale may actually be put up for sale because of their particular characteristics. Characteristics that may not have rented dwellings. One possible improvement would therefore be to find data on dwellings that are quickly bought and immediately rented afterwards. This would allow us to ensure that the dwelling in question is not intended only for one of the two sub-markets. Computing rent to price ratios this way improve the relevance of the rent to price ratio, however this method is not without issues either as it tend to ignore the case of homeowners.

In chapter 2 we show several results indicating the effect of social housing construction on housing prices. However, in this analysis we were not able to take into account the impact of different types of social housing. We have only presented results using the aggregated quantity of social housing. However, not all social housings are the same. There are three major types of social housing in France and their renters are different. It is likely that each type of social housing does not impact the housing market similarly. In addition, there are also limits regarding our discontinuity regression. Since we focus only on small municipalities, the sales volume is low. For this reason we have few statistical individuals in all discontinuity regressions. Furthermore, these results could be improved by using individual data on social housing collected over a longer period of time. By knowing the date of construction as well as the type of social housing, it would be possible to estimate more precisely the impact of the construction of social housing and whether each type of social housing implies a decrease

in the price of the surrounding private housing.

Chapter 3 also presents some limitations. The first flaw is the absence of data on rental housing for the years 2015 and 2016. The lack of data on this subject prevents us from continuing the analysis on the rental market. Observing what is happening in the rental market would allow us to be more conclusive on the total impact of the PINEL law reform. This is an important limitation because the impact of the reform is one of the results of the model. Another limitation concerns the amount of data we have after the reform is implemented. We do not have a very large number of sales following the implementation of the public policy.