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# **Residential Property Prices and Rents in a Spatial Context**

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## Thesis Abstract:

*The first two chapters aim at estimating the spatial consequences of prices and rents when hit by a national mortgage interest rate shock. In order to identify the effect, I leverage a novel dataset of local prices and rents of residential properties in Italy and a novel shift share instrumental variable identification design which relies on the different mortgage pick up rates by different age groups. I find that prices, rents, price-to-rent ratios, population, and tenure choices all respond to a mortgage interest rate shock in an asymmetric manner both in magnitude and direction. In particular, richer location tends to have all higher responses in the aforementioned variables. The heterogeneous responses are useful in defining a new nuanced interpretation of price-to-rent ratios capturing both the financial and consumption nature of residential properties. I then construct a parsimonious spatial model aimed at capturing the heterogeneous effect of mortgage interest rates on both prices and rents. A structural estimation of the model, aimed at isolating the effect of the mortgage interest rate hike between 2021 and 2023, matches the observed heterogeneous responses and implies that a mortgage interest rate positive shock reduces spatial welfare inequality. The third chapter focuses on the distributional consequences of a property tax hike within an urban location. I exploit the spatial nature of the Italian property tax and the Berlusconi governments fiscal reforms of 2008-2014 to isolate the effect of the property tax on property prices. I find that property taxes reduce price dispersion, thus reducing wealth inequality, in a heterogeneous way across different residential markets.*

# 1 Chapter 1: The Heterogeneous Effect of Mortgage Rate Changes on Price-to-Rent Ratios across Space

## Abstract

The present chapter aims at estimating the spatial consequences of prices and rents when hit by a national mortgage interest rate shock. In order to identify the effect, I leverage a novel dataset of local prices and rents of residential properties in Italy and a novel shift share instrumental variable identification design which relies on the different mortgage pick up rates by different age groups. I find that prices, rents, price-to-rent ratios, population, and tenure choices all respond to a mortgage interest rate shock in an asymmetric manner both in magnitude and direction. In particular, richer location tends to have all higher responses in the aforementioned variables. The heterogeneous responses are useful in defining a new nuanced interpretation of price-to-rent ratios capturing both the financial and consumption nature of residential properties.

**JEL codes:** E22, G12, G21, R21, R23, R31.

## 1.1 Introduction

Unlike a wide class of goods, residential properties can be traded on two different markets with two distinct prices. Either a property is traded on the transaction market, with a price attached to it, or it can be traded on the rental market. The existence of both prices and rents and their relationship, thus, is a specific characteristic of residential properties which has attracted the interest of economists in the past.

There are two key interpretations with respect to this dual nature of housing. The first interpretation, which I will refer to as the financial one, relies on the asset nature of residential properties. An investor might be interested in acquiring an housing property to supply on the rental market, and thus it reads the price as the cost of the investment and the expected stream of rents as the expected returns. In the real estate market, it is referred to as the cap-rate, and captures exactly the returns of a real estate investment. In its simplest formulation, which I refer to as the Classical Gordon Growth Valuation Formula, assuming there are no arbitrage opportunities and a reasonably competitive real estate market, the price should be equal to the expected stream of rents, net of the operating costs.

The second interpretation relies on the consumption nature of housing for both home-owners and renters. Let me consider the most extreme case here as well, with both rental and residential

properties supplied by the private sector and a housing market which is perfectly segmented, with two groups of agents, one which exclusively buys and the second which exclusively rents. If these two groups of agents have different geographical preference it will generate different price-to-rent ratio simply through different local demand functions. If we consider the Italian data on home-owners we observe that, on average, they are older and richer than renters, which suggests that some market segmentation does exist, if only driven by the existence of the housing life cycle ladder.

To disentangle these two interpretations, I will consider an exogenous variation in local mortgage rates and its effect on both prices and rents. The first order effect would be to make housing more costly than renting, which would allow us to distinguish between the two interpretations. In a world described perfectly by the financial interpretation, I would expect prices and rents responses to be positively correlated within a location, while price-to-rent ratios either remain constant or fall. On the other hand, a world described by the relative preference interpretation, would have more varied response based on the how elastic the location and tenure choice of the households are. There are two issues in the literature when trying to estimate the relationship between mortgage rates, prices, and rents. The first one is that the residential properties are not supplied at random on different markets, but tend to be different in quality. Previous research has struggled to compare the same type of properties on the different markets. I leverage an Italian dataset assembled by the Italian Fiscal Agency which oversees the Italian cadastre with authority over all rental and property contracts which provides both prices and rents for properties of different quality and purposes across the country. The second issue is the endogeneity between prices, rents, and the local mortgage interest rate does not allow to estimate the unbiased relationship between the three variables. To overcome the issue I employ a shift-share instrumental variable approach. The shift-share part of the identification strategy relies on the observation that different age groups tend to have different mortgage pick up rates when buying a property. Thus if I consider two municipalities, one populated exclusively by agents older than 70 years old and one populated by agents 30 to 50 years old, the latter will be much more affected by a mortgage rate shock than the former. If the country is hit by a quasi randomly distributed supply driven mortgage rate shock, identified through a composition of eurozone mortgage rates as the instrumental variable, then I am able to correctly identify the causal effect of mortgage rates on both prices and rents.

The present research finds that the price and rent responses are not fully consistent with either interpretation. I observe that price and rent responses are positively correlated within locations, consistent with the financial interpretation, while the price-to-rent ratio responses are not exclusively

negative, which is more consistent with the relative preference interpretation. Supporting the latter interpretation, I also find that location and tenure choices respond to a national mortgage rate shock. All responses are positively correlated in magnitude with the local wages. I further rationalize the findings through a general spatial and tenure reallocation of agents.

### 1.1.1 Literature Review

The housing market has been extensively studied in economics due to the necessity of households to consume housing units and its implication in the macroeconomic literature, in particular after the 2008 financial crisis as reported by Piazzesi and Schneider, [2016](#).

The current work can be inscribed into three strands of literature, the first revolves around the literature on price-to-rent ratios, the second on the spatial distribution of housing prices, and the third on the relationship between mortgage rates, prices, and rents.

The underlying problem behind the price-to-rent ratios is the tenure choice of agents. When the problem was approached by economists in the US, see Henderson and Ioannides, [1983](#) and Poterba, [1984](#), revolved around the specific nature of the US tax system and the no arbitrage condition for the residential property asset. Thus, the problem of the tenure choice was often approached from the point of view of asset valuation as in Krainer and LeRoy, [2002](#), where the baseline formula was analogous to Gordon and Shapiro, [1956](#) equating the price of the asset to the expected stream of rents. See for instance Campbell, Davis, Gallin, and Martin, [2009](#) which runs a decomposition of price-to-rent ratios based on the Gordon Growth Valuation Formula. More recently Sommer, Sullivan, and Verbrugge, [2013](#) builds a richer model, but still makes assumption on the underlying quality of properties for sale and rental ones in order to match the observed macroeconomic patterns. On the empirical side, the main issue has been identifying similar properties to run valid comparison between prices and rents. The paper by Moktan, [2025](#) highlights the fact that we can expect properties of lower quality to be supplied on the rental market rather than the property transaction one. Papers have overcome this problem through rich datasets of housing properties, like Ahlfeldt, Heblich, and Seidel, [2023](#) and Begley, Loewenstein, and Willen, [2019](#), or through specific identification strategies, like Bracke, [2015](#).

The second question regarding the distribution of prices is the location choices of agents. The seminal paper of Roback, [1982](#) applies a no arbitrage condition between locations to capture the determinants of housing prices in different regions. The baseline approach has informed a wide variety of papers, such as the one of Glaeser, Gyourko, Morales, and Nathanson, [2014](#) which introduces local

expectations, and was augmented with extreme value distributed shocks to give rise to the recent literature on large spatial models (I report Ahlfeldt, Redding, Sturm, and Wolf, [2015](#) and Redding and Rossi-Hansberg, [2017](#) as general references). Similar to the tenure no arbitrage literature, more recent paper has provided richer models leveraging on the large spatial model literature in order to capture the consequences of geography such as Giannone, Li, Paixão, and Pang, [2023](#) and Suzuki, [2023](#).

The interaction between the two choices has been less studied without making swiping assumptions in the modelization. The main reference is the paper by Glaeser and Gyourko, [2007](#) which questions the no arbitrage condition of the tenure and location choices when taken individually and spearheaded an approach which takes into account the two choices and the agent heterogeneity when studying price-to-rent ratios. More recently Van Nieuwerburgh and Weill, [2010](#), Vanhapelto, [2022](#), and Favilukis, Ludvigson, and Van Nieuwerburgh, [2025](#) try to capture both choices in a rich model, but need to take stringent assumptions in order to maintain some dynamic elements of their models.

The literature on the effect of mortgage interest rates, and the wider monetary policy, is rich. The main findings have been that an increase in mortgage interest rates should increase rents, as reported by Gete and Reher, [2018](#) and Dias and Duarte, [2019](#), while a decrease in mortgage interest rate increases house prices as reported by Akgündüz, Dursun-de Neef, Hacıhasanoğlu, and Yılmaz, [2023](#).

The present chapter inserts itself in the literature focusing narrowly on the effect of mortgage rate shocks on both prices and rents considered at the same time in a geographical set-up. The correct identification of these effects would help us in disentangling the different interpretations of the price-to-rent ratios proposed by the literature, providing new evidence toward a coherent and global one.

In this chapter in order to correctly identify the effect of mortgage interest rates on prices and rents I leverage international mortgage supply shocks, similar to Autor, Dorn, and Hanson, [2013](#), with a shift share approach. The shift share instrumental variable has been recently formalized by two papers, Goldsmith-Pinkham, Sorkin, and Swift, [2020](#) and Borusyak, Hull, and Jaravel, [2022](#), where the former focuses on the exogeneity of the share side of the identification strategy and the latter on the quasi-random distribution of the shocks. In this paper I will follow the quasi-random shock distribution interpretation rather than the exogenous shares one.

## 1.2 Data Collection and Empirical Strategy

The aim of this chapter is to estimate the elasticities of residential real estate prices and rents across different local labor markets. There are two difficulties in running this estimation, the first one relies on the quality of the underlying data and the second one regards the endogeneity of the two variables. In the next paragraph I'll show how this paper solves both in a novel way.

Before describing the two problems it is necessary to further examine the nature of the price-to-rent ratios. As explained in the introduction real estate properties can be traded on two different markets: the residential market and the rental market. This dual nature of real estate properties implies that to each real estate good two different prices can be attached, the real estate prices and the rental prices (which I will refer to respectively as prices and rents from now on to alleviate the discussion). As the underlying good is essentially the same, the relationship between the two prices is an interesting object per se and has been studied by the literature. The traditional interpretation of the relationship between the two has been analogous to the interpretation of financial stocks. If we interpret a residential property as an asset, due to its durability, which has a rate of return equal to the rent. Thus the price-to-rent ratio has a financial interpretation, the cap-rate. On the other hand, assuming that once a residential property is built, it is easy to provide it on either of the two markets, the local price-to-rent ratios must capture differences in the demand between real estate traded properties and residential rented ones.

The historical problem of working with data regarding the price-to-rent ratios revolves around the standard statistical adage of comparing apples with apples. Comparing local posted prices and posted rents would rely on the assumption that the traded properties on the two markets are comparable and do not differ in either size or quality. If different properties were traded on the two markets, then the price-to-rent ratios would capture not only the financial information and the local preferences, but also the intrinsic property differences between the two good. In order to avoid the issue I leverage a novel, to the best of my knowledge, dataset provided by the Italian cadastral authority. The *Osservatorio Mercato Immobiliare* (OMI) aggregates information from the contracts regarding both residential transactions and rental ones registered at the Italian cadaster which allows me to compare similar properties across the two markets.

The second issue regards the endogeneity between the mortgage interest rates and the prices and rents. In order to isolate the effect of mortgage interest rates on prices and rents I will run a shift-share instrumental variable regression based on different mortgage pick up rates across different demographic groups.

### 1.2.1 Data Collection

I collect data from different sources. The main source is the OMI dataset which collects data on prices and rents of all properties registered in the Italian cadaster based on their registered purpose and quality. The OMI divides quality into three categories (low, normal, and high) and purpose in four categories (affordable housing, civilian housing, lordlike housing, and detached housing). By law all real estate transactions have to be registered at the cadaster as most rental contracts<sup>[1]</sup>. The cadastral agency provides the data each semester starting from the first semester of 2004 until the second semester of 2023 dividing the whole national territory in different OMI zones, defined as socially and economically homogeneous<sup>[2]</sup>. These OMI zones are sub-municipal, for instance there are between 40 and 50 OMI zones in the city of Milan and over 200 for the city of Rome. Collecting prices and rents for similar properties across time, we are able to overcome the difficulties of comparing properties of similar qualities on the two different market. The OMI provides as well data regarding the stock of available residential properties in a given municipality.

I use, then, data from the Italian statistical agency (ISTAT) on yearly municipal population between 19 and 70 years old by age from 2003 to 2023. I aggregate them over the following age groups: 19-25, 26-30, 31-40, 41-50, 51-60, and 61-70. From the ISTAT I also download the yearly municipal pre-tax local average wages collected between 2012 and 2021, the yearly provincial inflation rates, and the yearly regional rates of home-ownership.

From the Italian Central Bank I use the regional mortgage rates, aggregated by semester. Similarly, I download from the European Central Bank the set of semestral mortgage interest rates in each country of the Eurozone.

In order to assess the spatial heterogeneity of mortgage rates I leverage the Italian local labor markets. The Italian statistical agency constructs these spatial aggregation of municipalities based on local commuting patterns every 10 years, which should capture the areas where households work and live. I consider the 2011 labor market map which I report in the appendix figure [14](#).

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<sup>1</sup>Only below 30 days rental contracts are excluded. By convention, in Italy, most residential contracts are of the '4+4' type, where the parties agree on a 4 years rental contract to be renewed with precedence for another 4 years.

<sup>2</sup>The OMI provides minimum and maximum local prices and rents. Given the spatial construction I assume that local properties do not differ within purpose and quality in each OMI zone. Given this construction it is reasonable to assume that local prices and rents are uniformly distributed and we can take the average of the extremes.

### 1.2.2 Empirical Strategy

Our relationship of interest is the causal effect of mortgage interest rates on both prices and rents. I will first describe the OLS regression equivalent before presenting the causal shift-share instrumental variable approach. The regression equation is:

$$\log y_{i,t,q} = \alpha + \beta \log \tau_R + \gamma_m + \gamma_{LLM,t} + \gamma_q + \varepsilon_R. \quad (1)$$

Where I index with  $i$  the OMI zone, with  $m$  the municipality, with  $R$  the region, and with  $q$  the quality and purpose of an observation. I also add a battery of semester fixed effects, one per local labor market in order to account for the local economic trends. I indicate with  $y$  the variables of interest, in our case prices, rents, and the price-to-rent ratios. The independent variable of interest  $\tau_R$  is the local mortgage rate. Lastly, standard errors are clustered at the regional level.

It is clear that such regression would suffer from endogeneity and would not capture the local causal effect of mortgage rate changes on prices and rents. Consider the context of asymmetrical regional growth during an economic expansion, regions where the growth is more pronounced will experience both higher interest rates and higher residential property prices and rents. To correctly estimate the causal effect of mortgage interest rates on housing prices and rents I design an identification strategy to overcome the potential endogeneity. I will leverage an instrumental variable shift-share approach.

A shift-share regression relies on different levels of exposure to a shock by different groupings of observations. There are two interpretations of the strategy which influence the interpretation of the results and the necessary assumptions and conditions for the validity of the estimation. Either the shares are exogenous, or the shocks are quasi-randomly assigned. I will follow the latter strategy, described by Borusyak et al., [2022](#). In this case, we need to assume that the shocks are distributed quasi-randomly with respect to the unobservables, or in other words that the shocks are not assigned strategically and that the shocks are mutually uncorrelated given the unobservables and that the sample is large enough for the shock-level IV. Notice how it is not a requirement for the shares to be exogenous with respect to the realization of the shocks.

The novel SSIV strategy I deploy relies on the observed relationship between mortgages take up rates across demographic groups and the different spatial concentrations of demographic segments across Italy. Regarding the first relationship, the OMI reports that the likelihood of households relying on mortgage financing varies across ages. In particular, it increases initially as younger agents become more likely to overcome the borrowing constraints, reaching the highest likelihood

for agents between 31 and 40 years old, and then starts declining as the accumulated savings allows some households to buy residential properties without financing.

| Age class | Percentage of borrowers |
|-----------|-------------------------|
| Up to 30  | 64%                     |
| 31 - 40   | 70%                     |
| 41 - 50   | 56%                     |
| 51 - 60   | 36%                     |
| 61 - 70   | 18%                     |
| Over 70   | 5%                      |

Table 1: Distribution of buyers per age class who take a mortgage when buying a residential property. Source: Ghirardo and Marignoli, [2023](#), published by the OMI, based on transaction level data.

Given the observed data it is reasonable to assume that residential transactions in municipalities with a younger population, buyers will be more likely to be affected by shifts in mortgage rates. Consider, in this sense, two thought locations, one populated by older agents and one by thirty years old, the same mortgage rate hike should lower the demand in housing, in a partial equilibrium, in the second location more than in the first one. Given that the Italian population is not distributed equally across the country according to their age, a national mortgage rate hike will have a different impact across different locations. In figure [1](#) one can observe that the younger population is concentrated in the Po Valley in the north, around Rome in the centre, and around the main urban areas in the South. Conversely, the older Italian population is concentrated in mountainous areas across the country.

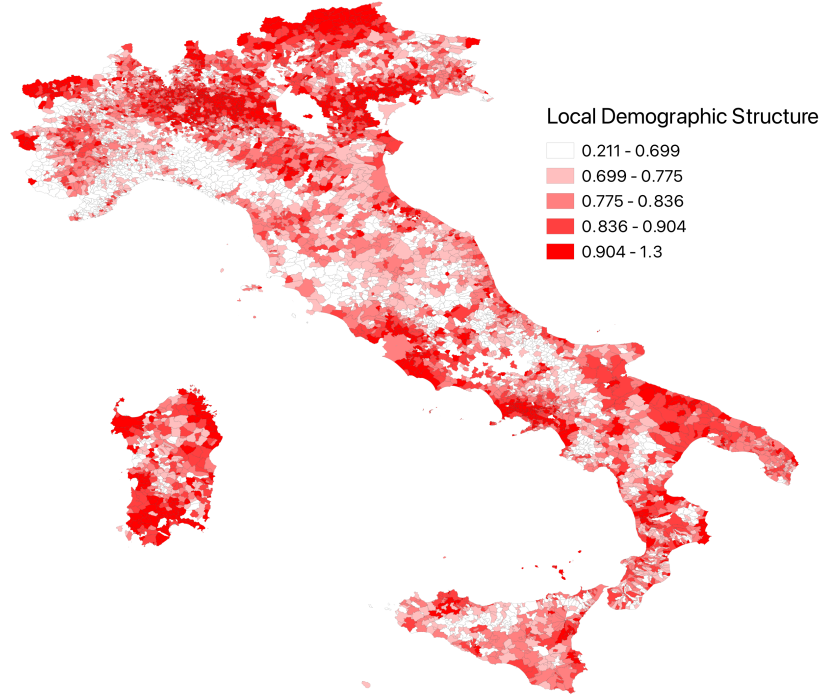


Figure 1: Map of Italian municipalities highlighted on the rate of 18-50 years old residents with respect to everyone else.

I will use the rates in table 1 together the demographic composition in order to construct the exposure shares in the SSIV estimation. It is possible, though, that the local demographic composition also affects the market for residential properties dampening the estimated relationship between mortgage rates and demographic shares. The key assumption of this strategy is that locations that are relatively younger tend to be more affected by shifts in local mortgage rates. However, if the residential market is driven by older agents, there is a risk that changes in the mortgage rate would not shift prices as much as required in order to compute a valid estimation. In such a case, in fact, the segment of buyers affected by different financing conditions would not imply large shifts in the aggregated demand for housing. The data reported in table 2 shows that, contrary to the previous thought experiment, most of the Italian residential property buyers are in the 31-50 age group.

| Age class | Share of buyers |
|-----------|-----------------|
| Up to 30  | 12%             |
| 31 - 40   | 24%             |
| 41 - 50   | 25%             |
| 51 - 60   | 21%             |
| 61 - 70   | 12%             |
| Over 70   | 6%              |

Table 2: Share of buyers of a specific age class. Source: Ghirardo and Marignoli, [2023](#), published by the OMI, based on transaction level data.

I can, thus, construct the exposure rate for each Italian municipality in a given year with the following formula:

$$e_m = \sum_a s_{m,a} t_a \quad (2)$$

Where I index with  $m$  the municipality and with  $a$  the age group. I indicate with  $s_{m,a}$  the share of residents of municipality  $m$  of age group  $a$ , and with  $t_a$  the mortgage take-up rates as reported in table [1](#). Local age exposure is computed for year 2004. Additionally, I exclude from the local population agents that are either below 19 years old or are over 70 years old. Thus, the shift-share OLS regression would be:

$$\log y_{i,t,q}^{e_i} = \alpha + \beta \log \tau_R^{e_m} + \gamma_i + \gamma_{LLM,t}^{s_m} + \gamma_q^{s_m} + \varepsilon_R. \quad (3)$$

Where the superscript  $e_i$  indicates the variable is interacted with the exposure shares and the superscript  $s_i$  indicates the variable is interacted with the local sum of shares, as required by Borusyak et al., [2022](#), in case that the sum of shares used to construct the exposure share does not sum to one. In my case I exclude the population that are less than 19 years old and more than 70 years old. It is important to highlight that the interpretation of  $\beta$  as the, causal, elasticity of prices and rents with respect to changes in mortgage rates is unaffected due to the inclusion of the exposure shares on both sides of the equation.

The last component of the empirical strategy is an instrumental variable regression in order to capture the causal effect of mortgage interest rates on prices and rents. I leverage an identification strategy analogous in spirit to the one used by Autor et al., [2013](#). I construct an index of Eurozone commercial mortgage rates and I then instrument the Italian local mortgage interest rates. If the European mortgage markets are hit by the same supply shift, and we control for national time trends, I should be able to correctly isolate exogenous shift with respect to local housing and rental market. A possible example would be a shift in the ECB monetary policy which would hit all Eurozone countries equally and should not be driven strategically taking into consideration the spatial distribution of Italian price-to-rent ratios and the local demographic distribution.

I, additionally, run a set of robustness checks as described in the literature. In particular, in order to test the random assignment of the shocks, I run the same regression as described in equation [3](#) considering the lagged prices and rents by 5 years. A significant estimated relationship in the pre-trend estimation would not be consistent with the shift-share assumption described in the previous section.

A possible critique against the described strategy is that European or international economic shocks would hit local Italian markets differently, in a way that is correlated to local economic dynamism, local demographic distributions, or local housing and rental markets. In other words, that the instrument is distributed strategically across different locations according to unobservable characteristics. The shift-share identification design, in fact, relies on two elements: that the shocks are not distributed strategically across locations and that there are enough shocks that are uncorrelated given the unobservables. Given the historical asymmetry between northern and southern Italy, just to consider the most macroscopic ones, it is a serious critique. Locations that are more economically dynamic, and are generally younger, tend to have more dynamic mortgage interest rates which could confound the results by capturing local economic activity heterogeneity, rather than the response to a mortgage rate shock. While the risk of strategic shock distribution should be captured by the instrument choice, I account for the local labor market economic context through a battery of location specific time fixed effects  $\gamma_{LLM,t}$ . The identification strategy would now be weakened if there is a correlation between within local labor market economic trends and mortgage interest rates. Given the definition of local labor markets based on household mobility, I expect that local financial markets are competitive and complete and that there aren't different economic trends across municipalities, thus validating the identification strategy assumptions.

In order to capture the potential heterogeneity I proceed with two different estimation strategies.

The first one implies shifting the estimate of the elasticity based on a local observable variable. In this paper I do so by interacting the local mortgage rate with the local pre-tax observed wages. The regression equation described in [3](#) is, thus, augmented in the following manner:

$$\log y_{i,t,q}^{e_m} = \alpha + \beta \log \tau_R^{e_m} + \beta_m w_{2012,m} \log \tau_R^{e_m} + \gamma_m + \gamma_{LLM,t}^m + \gamma_q^{s_m} + \varepsilon_R. \quad (4)$$

Where local wages  $w_{2012,m}$  are taken for the year 2012 and kept constant across different time periods. The aim is to capture only the income ordering of Italian municipalities and avoid potential correlation of local wages with the unobservables<sup>3</sup>. The current estimation loses interpretability of the results, in favor of capturing the potential local heterogeneity in price and rent responses. Given this loss, it is important to stress that I am interested chiefly in the sign of  $\beta_m$ , which governs the heterogeneity in responses.

The second strategy is aimed at better capturing the magnitude of the local responses. To do so I repeat the estimation described with equation [3](#) for each local labor market, sampling observations of the area under consideration. I can then run a regression between municipal observed wages and estimated responses and the estimated parameter should have the same sign as  $\beta_m$  of regression in equation [4](#).

Lastly I repeat the empirical estimations described in equations [4](#) with a battery of additional dependent variables. Specifically, I consider local population density and the local share of renters. A set of significant estimated parameters would be consistent with a redistribution of agents across locations and tenure choices, thus indicating that any mechanism explaining heterogeneity in prices and rents responses should account for the possibility of household reallocation.

### 1.2.3 Theoretical Interpretation of Price-to-Rent Ratios

Before delving into the results of the empirical analysis it is important to describe the price-to-rent ratios from the standard perspective in the literature. The literature stresses the financial interpretation of price-to-rent ratios, both as a methodological shortcut and as a practical tool for real estate market analysis. The standard interpretation relies on the durability of the housing good and the existence of the rental market. Let us consider an investor who buys a property in order to supply it on the rental market. If markets are complete and perfectly competitive it will follow

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<sup>3</sup>The underlying assumption is that in the past 25 years the income ordering of Italian municipalities has not changed much.

that the price the investor is willing to pay for the asset, including the mortgage repayment, is the expected return of the real estate asset, the future stream of rents:

$$(1 + \tau) p_0 = \sum_{t=0}^T \beta^t r_t \quad (5)$$

This formula is reminiscing of the price of a stock as the future expected stream of dividends that the company is expected to distribute, the Classical Gordon Growth Valuation Formula (CGGVF), with the inclusion of an investment cost wedge.<sup>4</sup> If we assume that the growth of the local economy is constant,  $g$ , and that rents grow at the same rate, and that there exists a safe asset with constant price  $\rho$ , then we can rewrite the formula above as:

$$\frac{p_0}{r_0} = \frac{1 + g}{(\rho - g)(1 + \tau)} \quad (6)$$

As such, if we take the CGGVF as the framework of interpretation, the spatial differences in price-to-rent ratios can be attributed to two different factors. Either there are geographical differences in the access to the financial markets or in the local discount rates (local differences in  $\rho$  and  $\tau$ ), or there are differences in the expected growth rates of rents (differences in  $g$ ). There are two issues if the interpretation of the price-to-rent ratios strictly follow the CGGVF. The first one is that the spatial variation in price-to-rent ratios is highly granular. It is difficult to explain through these two elements, variations in price-to-rent ratios within municipalities. Households can pick the preferred financial products among those offered by different financial institutions, at least within local labor markets. Similarly, expectations on future growth should be similar within a given municipalities. As I show in figure 2, which displays the price-to-rent ratios of properties of similar quality and purpose in the municipality of Milan, there exist wide differences in price-to-rent ratios within local geographical areas.

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<sup>4</sup>In the companion chapter to this one, the second one, I will deepen the analysis of the CGGVF and its implications from a theoretical point of view.

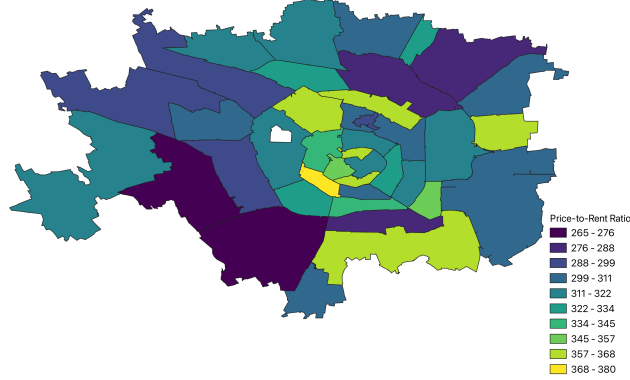


Figure 2: I report the price-to-rent ratios for each OMI zone in Milan in 2019 for residential properties of similar purpose and quality. It is difficult to explain the variation in local price-to-rent ratios exclusively through the CGGVF as both financial market access and growth expectations should not vary significantly within municipal areas.

The second lens of interpretation requires to assume that the households that trade residential asset on the two markets, the property and the rental ones, are slightly different. As such, the price-to-rent ratios should provide information on preferences with respect to the tenure and the rental location choices of households. In this context, given the non-tradability of the housing good once it is built, local differences in the price-to-rent ratios signal different crossings of local demand and supply curves. In this context it is easier to rationalize local differences in price-to-rent ratios, which are puzzling if studied exclusively through the lenses of the CGGVF. As an example, let us consider an extreme case where agents below the age of 50 exclusively rent and agents above the same age exclusively own. If these two groups have different location preference, I should expect, everything else equal, that the location that attracts more the younger half of the population shows lower price-to-rent ratios, than the other one. Additionally, it is possible to explain the empirical results of the literature. Akgündüz et al., [2023](#) find that the effect of mortgage rates hikes on prices is a negative one, as it depresses the demand for home-ownership. If we take the CGGVF as given, then we should expect that either the same is true for rental prices, but Gete and Reher, [2018](#) finds instead that the opposite is true, or that the changes are such that price-to-rent ratios fall, proportionally to local mortgage rate levels. If we go back to the local demand and supply framework, these results

can be explained by a decrease in the demand for home-ownership, together with an increase in the demand for rental properties.

The empirical analysis aims, also, at further disentangling these two explanations. At the same time I expect that these two interpretation should co-exist in determining the local price-to-rent ratios.

### 1.3 Regression Analysis

#### 1.3.1 OLS Regression Analysis

The objective of this chapter is to estimate the causal relationship between local mortgage rates and residential properties prices, rents, and price-to-rent ratios. First, I provide in table 3 the estimated parameters of the OLS regression described in equation 3. Table 3 provides result both for the regression at the national level for prices, rents and price-to-rent ratios respectively in columns (1), (3), and (5), and for the heterogeneous local elasticities respectively in columns (2), (4), and (6).

|                                   | Prices             |                       | Rents             |                    | Price-to-Rent       |                    |
|-----------------------------------|--------------------|-----------------------|-------------------|--------------------|---------------------|--------------------|
|                                   | (1)                | (2)                   | (3)               | (4)                | (5)                 | (6)                |
| Interest Rates                    | -0.0462<br>(0.275) | -0.413*<br>(0.220)    | -0.180<br>(0.391) | -0.355<br>(0.264)  | 1.134***<br>(0.135) | -0.0583<br>(0.164) |
| Interest Rates<br>× Log of Income |                    | 0.0374***<br>(0.0132) |                   | 0.0178<br>(0.0140) |                     | 0.0196<br>(0.0125) |
| Quality FE                        | Yes                | Yes                   | Yes               | Yes                | Yes                 | Yes                |
| Municipality FE                   | Yes                | Yes                   | Yes               | Yes                | Yes                 | Yes                |
| Semester × LLM FE                 | Yes                | Yes                   | Yes               | Yes                | Yes                 | Yes                |
| N                                 | 2'229'959          | 2'229'959             | 2'229'959         | 2'229'959          | 2'229'959           | 2'229'959          |
| R-sq                              | 0.888              | 0.888                 | 0.864             | 0.864              | 0.958               | 0.754              |

Table 3: All variables are in log terms. Income is measured as in 2012. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional level for columns (1), (3), and (5), and at the municipal level for columns (2), (4), and (6).

The regression reports a significant coefficient for the elasticity between price-to-rent ratios, including the mortgage rate, and the local mortgage interest rates. In particular, the point estimate of the elasticity is greater than 1 which implies that the price-to-rent ratios, without the mortgage rate wedge, increase. This is a result that would not be accounted in a CGGVF framework.

The regression analysis described in table 3, though, suffers from potential endogeneity between local prices and rents and the local mortgage interest rates. To account for this endogeneity I introduce the SSIV framework described in the previous section.

### 1.3.2 SSIV Regression Analysis

As I have described, the OLS regressions may suffer from endogeneity. As such I need to proceed with an identification strategy that would allow me to isolate the causal effect from mortgage rates to prices, rents and price-to-rent ratios. Therefore, I leverage the demographic SSIV strategy I described in the previous section, where I employ an exposure identification strategy which relies on the observation that agents of different ages tend to have different mortgage pick-up rates. In particular, as the local demographic composition varies across locations, older municipalities tend to be less exposed to a change in mortgage rates. For the two following regression I will not focus on the levels of the parameters estimated, rather on the spatial heterogeneity that is highlighted by the results. In table 4 I provide the results of the regression highlighted in equations 3 and 4.

|                             | Prices    |           | Rents     |           | Price-to-Rent |           |
|-----------------------------|-----------|-----------|-----------|-----------|---------------|-----------|
|                             | (1)       | (2)       | (3)       | (4)       | (5)           | (6)       |
| Interest Rates              | -0.117    | -0.633*** | -0.146    | -0.594**  | 0.786***      | 0.720***  |
|                             | (0.136)   | (0.205)   | (0.144)   | (0.236)   | (0.0549)      | (0.178)   |
| Interest Rates              |           | 0.0525*** |           | 0.0458**  |               | 0.00675   |
| $\times$ Log of Income      |           | (0.0175)  |           | (0.0197)  |               | (0.0169)  |
| 50 <sup>th</sup> Percentile |           | -0.121    |           | -0.148    |               | 0.720     |
| Quality FE                  | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| Municipality FE             | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| Semester $\times$ LLM FE    | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| N                           | 2'226'042 | 2'226'042 | 2'226'042 | 2'226'042 | 2'226'042     | 2'226'042 |
| R-sq                        | 0.944     | 0.944     | 0.874     | 0.864     | 0.971         | 0.754     |

Table 4: All variables are in log terms. Income is measured as in 2012. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional-year level for columns (1), (3), and (5), and at the municipal-year level for columns (2), (4), and (6).

As in the OLS analysis, the estimates of table 4 suggest the presence of spatial heterogeneity in the effect of interest mortgage rates on prices and rents. The results of columns (2) and (4) suggest that both prices and rent respond to a mortgage rate shock, in an heterogeneous manner across different locations. Furthermore the responses of prices and rents are positively correlated between them. Together with the results of column (5), which imply a price-to-rent ratio response, the estimated coefficients of table 4 suggest that the CGGVF is not able to explain the responses of prices and rents to a mortgage rate shock. In fact, the CGGVF would have implied no response in the price-to-rent ratio and a negative correlation between price and rent elasticities.

In order to better gauge the level of the local responses and to take into account the presence of local time trends, I repeat the analysis SSIV regression described in equation 4 limiting the sample to each of the Italian local labor markets. First I plot the results on the map of Italy in figure 3.

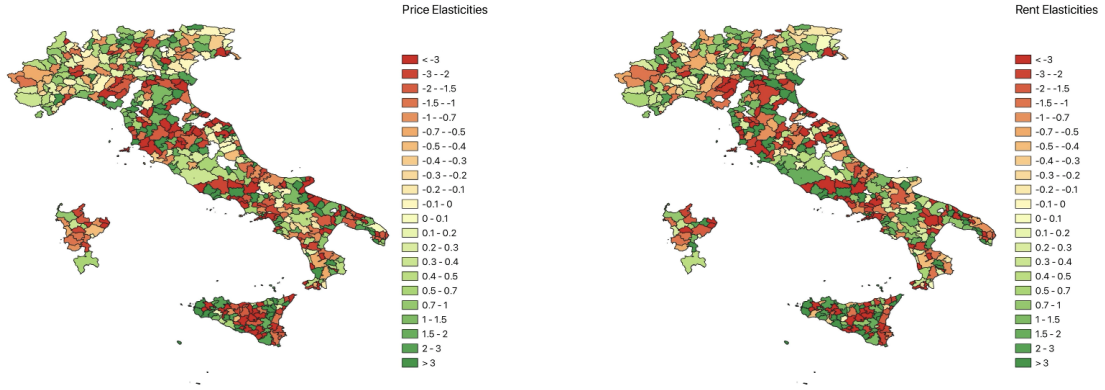


Figure 3: On the left I plot the estimated local price elasticities on the map of Italy. On the right I plot the estimated local rent elasticities. If the estimated elasticity is positive I plot the results in scales of green, while if the estimated elasticity is negative I plot the results in scales of red. I do not plot results of local labor market where the absence of data or matching issues lead to a failure of the local regression.

At a first glance of the results plotted in figure 3, it seems that there is a positive correlation between the two groups of estimations. Additionally, it does not seem that the estimated elasticities of rents are systematically higher of the estimated elasticities of prices, which would imply a systematic negative response in price-to-rent ratios.

In order to better analyze the estimated elasticities, I plot the histogram of the price and rent responses in figure 4.

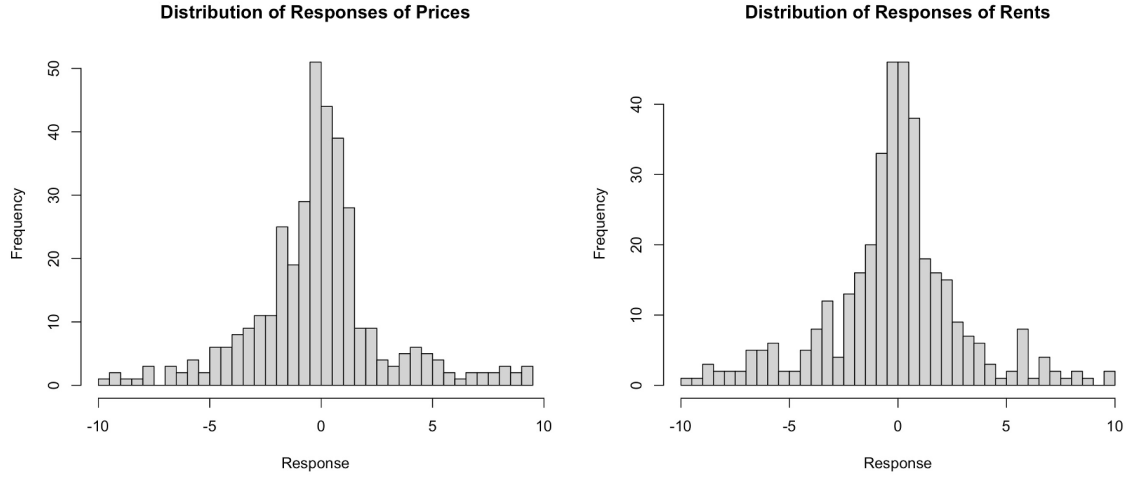


Figure 4: Histogram graphs of price, on the left, and rent elasticities, on the right, with respect to mortgage rate changes. Each observation refers to one of the Italian local labor markets.

As the previous regression, this battery of estimations highlights the spatial heterogeneity of local responses in prices and rents with respect to mortgage rates. In particular I highlight the fact that the local responses in prices and rents with respect to mortgage interest rate shifts can be either positive or negative. In order to be consistent with the CGGVF prices and rents should co-move in light of a local shock. In figure 5 I plot on the x-axis the elasticities of prices with respect to mortgage rates, while on the y-axis the elasticities of rents with respect to the mortgage rates, and each data point is a local labor market.

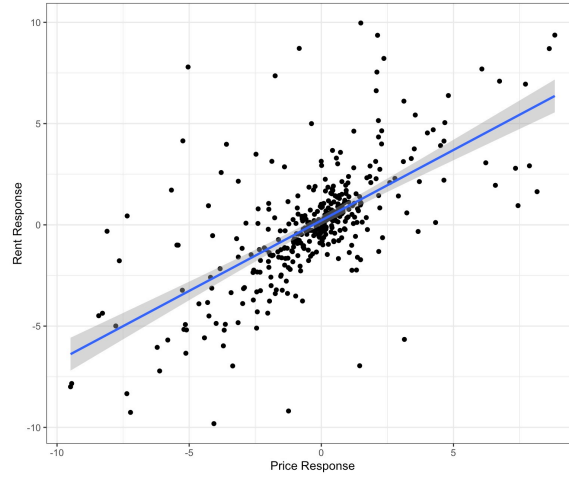


Figure 5: On the x-axis I plot the elasticities of prices with respect to local mortgage rates, on the y-axis I plot the elasticities of rents with respect to mortgage rates. Each dot represents an Italian local labor market.

In line with the previous estimations the scatterplot of figure 5 highlights a positive correlation between price and rent elasticities with respect to mortgage rates. In order to further test the CGGVF interpretation of price-to-rent ratios, I run a similar exercise to the one plotted in figure 4, with price-to-rent ratios as the dependent variable. According to the CGGVF as described in equation 6, any change in local mortgage rates should be negatively correlated with price-to-rent ratios. The results are plotted in figure 6.

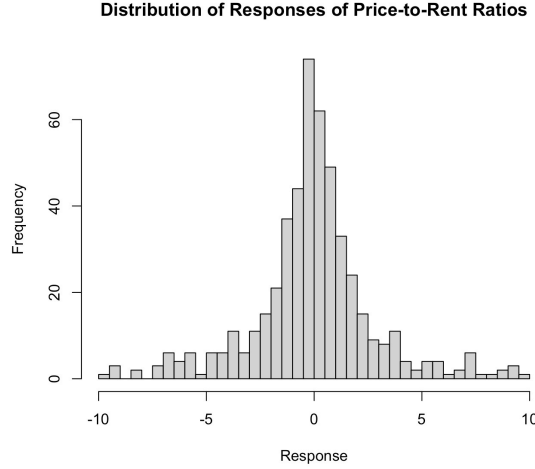


Figure 6: Histogram graph of price-to-rent elasticities with respect to mortgage rate changes. Each observation refers to one of the Italian local labor markets.

Similar to the results listed in table 4, the estimated coefficients are not consistent with the CGGVF interpretation of equation 6. The theoretical formulation implies a negative response in price-to-rent ratios to a positive mortgage hike, where I find that several locations observe a positive response of price-to-rent ratios.

### 1.3.3 Additional Results

In order to shed some additional lights on the underlying mechanism behind the local responses in prices and rents two additional SSIV regressions, as described in equation 4, with local population and the local share of renters as dependent variables. If the AGGVF interpretation holds, I should observe some causal movement of households across the location-tenure choices in response to a mortgage rate shock. Even though I don't expect the full Italian population to reallocate across tenure and municipalities after a mortgage rate shock, those households that face these decision will optimize accordingly. I report the results of these two regressions in table 5. In column (1) I report the estimation taking the local population as the dependent variable, while in column (2) I report the estimation taking the local share of renters as the dependent variable.

|                             | Population | Share of Renters |
|-----------------------------|------------|------------------|
|                             | (1)        | (2)              |
| Interest Rates              | 0.752***   | −0.159***        |
|                             | (0.120)    | (0.0453)         |
| Interest Rates              | −0.189**   | 0.00905*         |
| × Log of Income             | (0.0209)   | (0.00482)        |
| Municipality FE             | Yes        | Yes              |
| Semester × LLM FE           | Yes        | Yes              |
| 50 <sup>th</sup> Percentile | −1.087     | −0.0709          |
| N                           | 282'242    | 282'236          |
| R-sq                        | 0.999      | 0.996            |

Table 5: Regression in column (1) has the municipal population as the dependent variable, regression in column (2) has the local renter share as the dependent variable. All variables are in log terms. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors are clustered at the municipality-year level.

The results suggest that households respond to mortgage rate shifts by changing their tenure and location choices, which is consistent with the AGGVF interpretation of the price-to-rent ratio. In particular, there seems to be a population shift from richer, and more densely populated, locations in favor to poorer, and less populated, ones, when there is a positive mortgage rate shock. Similarly, in poorer locations there is an increase in the share of home-owners against an increase of renters in richer locations.

#### 1.3.4 Robustness Checks

I will run a set of robustness checks regarding the SSIV strategy in order to test its assumptions.

Even though the identification strategy does not rely on the exogeneity of the exposure share, I report in table 6 a balance check regressing  $e_m$  on local wages, population, housing prices, and rents all measured in the first available period.<sup>5</sup>

<sup>5</sup>2012 for local wages, 2004 for all other variables.

| Exposure Shares | (1)                       | (2)                    |
|-----------------|---------------------------|------------------------|
| Income          | 0.0367***<br>(0.000540)   | 0.0351***<br>(0.00380) |
| Population      | 0.00207***<br>(0.0000600) | 0.000743<br>(0.000569) |
| Housing Prices  | -0.00743***<br>(0.000515) | -0.00213<br>(0.00175)  |
| Housing Rents   | 0.00582***<br>(0.000468)  | 0.0000910<br>(0.00140) |
| Quality FE      | No                        | Yes                    |
| LLM FE          | No                        | Yes                    |
| N               | 43'802                    | 43'802                 |
| R-sq            | 0.206                     | 0.535                  |

Table 6: All dependent variables are in log terms. Income is measured as in 2012, all other dependent variables are measured in 2004. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level.

The result of the simple regression indicate that, aside from income, within local labor market variation in exposure shares is not correlated with local population levels, housing prices, and housing rents. On the other hand, locations with higher wages in a local labor market tend to be more exposed to a mortgage rate variation.

Following Borusyak et al., [2022](#), I will run a set of pre-trend regressions in order to capture whether the shocks are quasi-randomly distributed across locations.

The literature on shift-share highlights the importance of checking whether the regression is not significant when lagging the dependent variable or considering proxies of the unobserved variables, a 'pre-trend' test. In the context of the random shock shift share framework, as opposed to the independent shares one, the 'pre-trend' test allows us to check whether the shocks are truly randomly distributed. Given that past outcomes should not be influenced by a truly exogenous shock, a rejection of the null hypothesis would imply that either the shocks are distributed accordingly to the previous outcome variables, or that the shocks are distributed strategically across different locations.

There is a trade-off when deciding the amount of lags in the dependent variables, in particular when considering sticky ones such as real estate property prices and rents, and the loss in sample size. The specific bliss point I take is five years. I report the results in table 7, where columns (1) and (2) are the lagged equivalent of the SSIV with prices as the dependent variables, columns (3) and (4) are the lagged equivalent of the SSIV with rents as the dependent variables, and columns (5) and (6) are the lagged equivalent of the SSIV with price-to-rent ratios as the dependent variables. Additionally, I report in columns (1), (3), and (5) the results of the homogeneous SSIV described by equation 3 and in the remaining columns I report the results of the spatially heterogeneous SSIV described by equation 4

|                   | Prices |          | Rents    |          | Price-to-Rent Ratio |         |
|-------------------|--------|----------|----------|----------|---------------------|---------|
|                   | (1)    | (2)      | (3)      | (4)      | (5)                 | (6)     |
| Interest Rates    | 0.499  | 4.093    | 3.610    | 3.604    | -1.126              | -1.016  |
|                   | (8207) | (148899) | (149427) | (166246) | (75619)             | (39406) |
| Interest Rates    |        | -0.0581  |          | 0.00337  |                     | -0.0614 |
| × Log of Income   |        | (12.961) |          | (14.471) |                     | (3.44)  |
| Quality FE        | Yes    | Yes      | Yes      | Yes      | Yes                 | Yes     |
| OMI zone FE       | Yes    | Yes      | Yes      | Yes      | Yes                 | Yes     |
| Semester × LLM FE | Yes    | Yes      | Yes      | Yes      | Yes                 | Yes     |
| N                 | 35'144 | 51'724   | 51'724   | 51'724   | 51'724              | 51'724  |
| R-sq              | 0.817  | 0.730    | 0.653    | 0.653    | 0.740               | 0.739   |

Table 7: All variables are in log terms. Outcome variables are lagged by 5 years. Standard errors, clustered at the OMI zone level, are reported in parenthesis. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Columns (1) and (2) report results with prices as the dependent variable. Columns (3) and (4) report results with rents as the dependent variable, and columns (5) and (6) report results with the price-to-rent ratio as the dependent variable. Columns (1), (3), and (5) report results for the homogeneous SSIV described in equation 3, while the remaining columns report the results for the spatially heterogeneous SSIV described in equation 4. Standard errors are clustered at the region-year level in columns (1), (3), and (5) and at the municipality-year level in the other specifications

Given that we fail to reject the null hypothesis, the 'pre-trend' equations are consistent with the

assumptions of the SSIV framework of the paper. I run a set of similar equations with respect to the additional results. I report the results in table 8.

|                 | Population | Share of Renters |
|-----------------|------------|------------------|
| Interest Rates  | −0.444     | −2.532           |
|                 | (0.981)    | (1.498)          |
| Interest Rates  | 0.0400     | 0.214            |
| × Log of Income | (0.929)    | (0.159)          |
| Municipality FE | Yes        | Yes              |
| Year × LLM FE   | Yes        | Yes              |
| N               | 51'724     | 51'724           |
| R-sq            | 0.968      | 0.899            |

Table 8: All variables are in log terms. Outcome variables are lagged by 5 years. A '\*\*' indicates coefficients significant at the 0.1 level. A '\*\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors are clustered at the municipal-year level.

I now report a series of robustness check, alternative specifications, and sanity checks in order to validate the main results of the chapter. First, I report in table 9 the first stage of the regression between the Eurozone composite mortgage interest rate and the regional Italian ones.

|                                                   | Interest Rate             | Interest Rate $\times$ Log of Income |
|---------------------------------------------------|---------------------------|--------------------------------------|
| Eurozone Interest Rates                           | 1.048***<br>(0.140)       | 0.0322<br>(0.130)                    |
| Eurozone Interest Rates<br>$\times$ Log of Income | 0.000898***<br>(0.000140) | 1.0543***<br>(0.141)                 |
| N                                                 | 2'217'900                 | 2'217'900                            |
| F-statistics                                      | 1'493'296                 | 1'575'403                            |
| R-sq                                              | 0.997                     | 0.997                                |

Table 9: All variables are in log terms. Column (1) refers to the regression with the local interest rate as dependent variable, column (2) to the regression with the local interest rate  $\times$  the log of local income as dependent variable. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors are clustered at the municipality-year level.

As expected, the instrument is not weak. In both estimations all variables of interest are significant at the 0.01 level. Additionally the F-statistics allows us to reject the the null hypothesis.

The current estimates take as a unit of measurement prices and rents in an OMI zone for a given period and quality. Given that the entire national territory is divided into these zones, it is important to take into account the oversampling of poorer locations, given that income is highly concentrated in few locations. To account for this oversampling I re-run the SSIV estimation described in table 4 with a weight based on the local municipal population divided by the number of municipal OMI zones. I report the results in table 10.

|                                   | Prices              |                      | Rents                |                      | Price-to-Rent       |                      |
|-----------------------------------|---------------------|----------------------|----------------------|----------------------|---------------------|----------------------|
|                                   | (1)                 | (2)                  | (3)                  | (4)                  | (5)                 | (6)                  |
| Interest Rates                    | −0.372**<br>(0.168) | −0.950**<br>(0.341)  | −0.543***<br>(0.173) | −1.133***<br>(0.236) | 0.929***<br>(0.144) | 0.941***<br>(0.224)  |
| Interest Rates<br>× Log of Income |                     | 0.0816**<br>(0.0304) |                      | 0.0832**<br>(0.0330) |                     | −0.00169<br>(0.0196) |
| Quality FE                        | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  |
| Municipality FE                   | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  |
| Semester × LLM FE                 | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  |
| N                                 | 2'226'042           | 2'226'042            | 2'226'042            | 2'226'042            | 2'226'042           | 2'226'042            |
| R-sq                              | 0.892               | 0.892                | 0.843                | 0.843                | 0.957               | 0.957                |

Table 10: All variables are in log terms. Income is measured as in 2012. Observations are weighted on the local municipal population divided by the number of municipal OMI zones. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional-year level for columns (1), (3), and (5), and at the municipal-year level for columns (2), (4), and (6).

The coefficients estimated in table 10 are consistent with those in table 4 but larger in magnitude, meaning that the results of the main estimation are biased by an oversampling of smaller municipalities with respect to richer ones.

I now proceed to adopt an alternative IV in order to run a sanity check on the specification of table 4. To do so, rather than considering a composite Eurozone mortgage interest rate, capturing a set of supply side mortgage rate shocks common the Eurozone, I consider a variation in the ECB overnight interest rates. The main assumption is that, while the ECB takes into account national trends in price-to-rent ratios, it would not take into account local, as in within LLM, variations in the housing market.<sup>6</sup> I report the results in table 11.

<sup>6</sup>Central banks account for the price-to-rent ratio as a statistic capturing whether there is a bubble in the real estate markets.

|                                   | Prices            |                     | Rents             |                   | Price-to-Rent        |                     |
|-----------------------------------|-------------------|---------------------|-------------------|-------------------|----------------------|---------------------|
|                                   | (1)               | (2)                 | (3)               | (4)               | (5)                  | (6)                 |
| Interest Rates                    | −0.320<br>(0.264) | −0.920<br>(0.554)   | −0.302<br>(0.246) | −1.335<br>(0.891) | 0.748***<br>(0.0764) | 1.181**<br>(0.457)  |
| Interest Rates<br>× Log of Income |                   | 0.0611*<br>(0.0345) |                   | 0.105<br>(0.0709) |                      | −0.0441<br>(0.0496) |
| Quality FE                        | Yes               | Yes                 | Yes               | Yes               | Yes                  | Yes                 |
| Municipality FE                   | Yes               | Yes                 | Yes               | Yes               | Yes                  | Yes                 |
| Semester × LLM FE                 | Yes               | Yes                 | Yes               | Yes               | Yes                  | Yes                 |
| N                                 | 2'226'042         | 2'226'042           | 2'226'042         | 2'226'042         | 2'226'042            | 2'226'042           |
| R-sq                              | 0.944             | 0.944               | 0.874             | 0.873             | 0.971                | 0.971               |

Table 11: All variables are in log terms. Income is measured as in 2012. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional-year level for columns (1), (3), and (5), and at the municipal-year level for columns (2), (4), and (6).

The results are consistent with those estimated in table 4. As in the main estimation, I reject the null hypothesis of no response in price-to-rent ratios with respect to mortgage interest rate shocks, thus rejecting the CGGVF.

As an additional robustness check on the spatial distribution of the results, I run two further batteries of SSIV regressions. First I run two sets of SSIV regressions, as the one described by table 4, by restricting the samples based on two different criteria. In the first set of regressions, described in table 12 and 13, I restrict the sample based on local municipal wage. In table 12 I consider the municipality with local declared incomes lower than the 2012 median local income.

|                   | Prices    |           | Rents     |           | Price-to-Rent |           |
|-------------------|-----------|-----------|-----------|-----------|---------------|-----------|
|                   | (1)       | (2)       | (3)       | (4)       | (5)           | (6)       |
| Interest Rates    | −0.122    | 0.232     | −0.116    | 0.193     | 0.752***      | 0.802***  |
|                   | (0.148)   | (0.304)   | (0.110)   | (0.323)   | (0.0729)      | (0.218)   |
| Interest Rates    |           | −0.0338   |           | −0.0295   |               | −0.00469  |
| × Log of Income   |           | (0.0295)  |           | (0.0302)  |               | (0.0217)  |
| Quality FE        | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| Municipality FE   | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| Semester × LLM FE | Yes       | Yes       | Yes       | Yes       | Yes           | Yes       |
| N                 | 1'027'700 | 1'027'700 | 1'027'700 | 1'027'700 | 1'027'700     | 1'027'700 |
| R-sq              | 0.935     | 0.935     | 0.835     | 0.835     | 0.978         | 0.978     |

Table 12: All variables are in log terms. Income is measured as in 2012. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional-year level for columns (1), (3), and (5), and at the municipal-year level for columns (2), (4), and (6).

Again the result are consistent with the main estimation, in particular with respect to the behavior of the price-to-rent ratios. In table [13](#), instead, I restrict the sample to the top quintile of municipalities with respect to local 2012 incomes.

|                   | Prices  |          | Rents   |          | Price-to-Rent |          |
|-------------------|---------|----------|---------|----------|---------------|----------|
|                   | (1)     | (2)      | (3)     | (4)      | (5)           | (6)      |
| Interest Rates    | −0.207  | −0.353   | −0.284  | −0.348   | 0.830***      | 0.751**  |
|                   | (0.161) | (0.412)  | (0.195) | (0.457)  | (0.116)       | (0.322)  |
| Interest Rates    |         | 0.0176   |         | 0.00788  |               | 0.00969  |
| × Log of Income   |         | (0.0418) |         | (0.0451) |               | (0.0324) |
| Quality FE        | Yes     | Yes      | Yes     | Yes      | Yes           | Yes      |
| Municipality FE   | Yes     | Yes      | Yes     | Yes      | Yes           | Yes      |
| Semester × LLM FE | Yes     | Yes      | Yes     | Yes      | Yes           | Yes      |
| N                 | 376'301 | 376'301  | 376'301 | 376'301  | 376'301       | 376'301  |
| R-sq              | 0.868   | 0.868    | 0.807   | 0.807    | 0.958         | 0.958    |

Table 13: All variables are in log terms. Income is measured as in 2012. A '\*' indicates coefficients significant at the 0.1 level. A '\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors, reported in parenthesis, are clustered at the regional-year level for columns (1), (3), and (5), and at the municipal-year level for columns (2), (4), and (6).

Comparing the results of table [12](#) and [13](#), it is consistent with the spatial asymmetry of the main estimations, even though the results are noisier than the main estimation. In particular, I observe that the relationship between responses of prices and rents and mortgage interest rates does not vary linearly with respect to the local wage and that the effect of the responses in the richer municipalities dominates the one in the poorer ones. Additionally, I point out that there seems to be a positive correlation between price-to-rent ratio responses and local wages, with the additional fact that there seems to be a positive response in price-to-rent ratio with respect to mortgage interest rates, which is an additional element which is not consistent with the CGGVF.

## 1.4 Interpretation of the Results

I will now try to summarize the estimated results of the previous section. The objective of the empirical analysis is to quantify the causal relationship between local mortgage rates and both prices and rents. To do so, I employ a novel SSIV identification strategy relying on the different mortgage pick up rates of different age groups and the asymmetric spatial distribution of different

demographic segments.

The specific interest of this paper is to understand whether the relationship between mortgage rates and local prices and rents vary across locations and whether this difference would shed more light on the theoretical interpretation of price-to-rent ratios. The two interpretation, are connected with different expected price and rent behaviors under one national shock. The first interpretation, which I have referred to as the classical Gordon Growth Valuation Formula (CGGVF) interpretation, reads the price-to-rent ratio through the financial information it discloses. If we consider any residential housing unit as an asset with a return equal to the rent, it is possible to read the price-to-rent ratio as the cap-rate of the given asset. In other words, and similarly to stocks, the price of the asset has to be equal to the expected future flow of rents, as long as the different markets under consideration are competitive enough. The second interpretation, which I refer to the relative preferences interpretation, relies on the different relative local preference with respect to one or the other tenure choice. If we have two groups of agents with different preferences with respect to to owning and renting and these two groups distribute themselves asymmetrically across locations, everything else equal, I expect that the two prices would capture the different household behavior.

I described the expected local responses for the two interpretation under a common national mortgage rate shock in the second section of the current chapter. In particular, under the CGGVF interpretation, I expected that a hike in mortgage rate, leads to an increase in local prices and a decrease of the price-to-rent ratio, while, under the relative preference interpretation, I would expect a local decrease in prices and a corresponding increase in rents.

The results of the empirical estimation of the previous section is not consistent with either interpretation, suggesting that an exclusionary approach to the interpretation of the price-to-rent ratio, either as a financial or consumption object, is not consistent with the observed facts. The results of the empirical analysis suggest that the causal response of prices and rents with respect to a change in mortgage rates is highly asymmetrical across location, changing both in magnitude and sign. The higher the income of a location, in particular, the higher the elasticity of prices and rents with respect to local changes in the local mortgage rate. The elasticity of the price-to-rent ratio with respect local mortgage interest rates varies in an opposite manner across locations, even though the empirical result are less clear cut due to the higher sensitivity to errors of the result. The price and rent elasticities, thus, are consistent with the CGGVF interpretation, but the price-to-rent elasticities are not, as we would expect a null result. On the other hand, the spatial distribution of the elasticities and the different magnitude and direction of the different estimations

is more consistent with the relative preferences interpretation. More so, if I consider the result of the additional empirical results regarding tenure and location choices. The results regarding population and tenure choice suggest that agents shift their location preference in favor of locations with higher income after a positive national mortgage shock, while the share of renters increases in location with higher wages and decreases otherwise. The fact that households respond asymmetrically with respect to locations and tenure choices to mortgage rate changes, is consistent with the relative preference interpretation.

The empirical results and the following interpretation provides a greater understanding of the price-to-rent ratio and the context needed in order to study it. The main result of the empirical section is that there is a spatial asymmetry in price and rent responses, which underlay a potential spatial asymmetry in welfare responses. In the most extreme case, where the welfare response to a national mortgage rate shock is asymmetric both in magnitude and direction, such as that of prices and rents, any national policy affecting the mortgage rate would imply a spatial redistribution of welfare, which should inform policymakers tinkering with access to home-owning policies.

## 1.5 Conclusion

The aim of the paper was to disentangle the two different interpretations of the price-to-rent ratio leveraging an exogenous mortgage rate shock. The first interpretation of the price-to-rent ratio is a financial one, if I interpret a residential property as an asset with a return equal to the rent, and the financial market respects a set of assumptions, such as no arbitrage and perfect competition, then the price should be equal to the expected stream of rents. It follows the same formulation as a stock asset, which is equal to the expected stream of dividends. The second interpretation follows the assumption that either renting and home-ownership are not equivalent modes of consumption or the populations of renters and home-owners are, at least partially, different ones. Thus, the local crossing of demand and supply for both residential properties and rental ones determines the local prices and rents.

The two interpretations imply different outcomes. The financial interpretation assumes that the responses of prices and rents to a mortgage interest rate shock are positively correlated, while the response of the price-to-rent ratio is negative. The second interpretation is more nuanced and implies that the flows of agents across locations and tenure choices determines the local prices and rents. In this context an increase in local mortgage rates, increasing the cost of home-ownership, should cause a decrease in home-ownership demand and an increase in demand for rental properties. The

overall effect should be a fall in prices and an increase in rents, with no specific prediction regarding price-to-rent ratios.

I leverage a novel dataset regarding the Italian property and rental markets spanning the past 20 years in order to correctly capture prices and rents for similar properties. I also employ a novel instrumental variable shift share estimation strategy, which relies on the different mortgage pick up rates across different demographic groups and their asymmetric distribution across space. In other words I expect a supply-driven mortgage rate shock, instrumented by a composite Eurozone mortgage rate variable, has a different effect on prices and rents in an older location, where there are fewer transactions with lower probability of mortgage financing, than younger ones.

The findings of the paper are partially compatible with both interpretation, which is consistent with a dual-nature interpretation of housing properties, both as a financial asset and a consumption good. In particular I find that local price and rent responses are spatially unequal and positively correlated, which is consistent with the financial interpretation, and that price-to-rent ratio responses are not exclusively negative, which is instead consistent with the relative preference interpretation. In order to understand the determinants of the spatially unequal response I interact the responses with the local wage, finding that price, rent, and tenure choices responses are positively correlated with wages, while population responses are negatively correlated with local income levels.

Overall, the findings suggest that the households location and tenure choice responses with respect to a mortgage rate shock are fundamental in order to understand the responses of residential prices and rents. In addition, the spatial and tenure choice responses of households imply that national residential access and monetary policies are not neutral with respect to the interaction between geography and the housing market.

## 2 Chapter 2: The Gordon Growth Valuation Formula for Residential Real Estate Properties in a Spatial Context

### Abstract

In this chapter I construct a model aimed at capturing the heterogeneous effect of mortgage interest rates on both prices and rents. The model captures the dual nature of residential properties as financial asset with a return equal to the rent and durable consumption goods. A parsimonious static spatial model with households facing both a location and tenure choice, where home-owners who draw additional utility from owning properties and rental properties which are supplied by home-owners, is able to recreate a simple augmented version of the Gordon Growth Valuation Formula which captures the dual nature of the residential property. A structural estimation of the model, aimed at isolating the effect of the mortgage interest rate hike between 2021 and 2023, matches the heterogeneous responses estimated in the previous chapter and implies that a mortgage interest rate positive shock reduces spatial welfare inequality.

**JEL codes:** E22, G12, G21, R21, R23, R32.

### 2.1 Introduction

The literature on economic geography tends to simplify the market for residential properties either by limiting the market for housing to either the transaction one or the rental one, or by making swiping assumptions in order to make the models more manageable. The aim of this chapter, though, is to provide a theoretical and endogenous formulation for the local price-to-rent ratios by capturing both the financial interpretation of price-to-rent ratios, where prices capture their asset returns in form of rents, and the relative preference one, where the local price-to-rent ratios are determined by the local supply and demand of the two goods.

I construct a simple spatial model where agents decide the location and their tenure choice. Properties are supplied by a construction sector, while home-owners, once they have decided the amount of housing asset to buy, can further decide how much of their residential asset to supply on the rental market. Home-owners, thus, enjoy the consumption of housing properties, the additional budget from the rented properties, and an end of life utility from owning the asset, akin to a feel good bequest motive. In general, the model does not show any friction, other than a price wedge between builders and home-owners. Thus I am able to explain variations in the price-to-rent ratios through the local demand and supply of rental and residential properties.

The parsimonious model I build, generates an augmented version of the Gordon Growth Valuation

Formula. This augmented formulation is able to capture both the financial interpretation of price-to-rent ratios and the relative preference one. In fact, given a specific functional form, prices in the model are equal to rents plus an additional component which is a function of the local population of home-owners.

Lastly I run a structural estimation trying to isolate the consequences of the rise in mortgage interest rate that were observed between 2021 and 2023. Given the simplicity of the model I do not claim to capture the aggregate welfare change, but the model is still able to recreate the dispersion of responses in prices, rents, price-to-rent ratios, location, and tenure choices as observed in the previous empirical chapter. I also observe that the welfare response for both home-owners and renters are asymmetric across locations, thus the mortgage rate hike was equivalent to a welfare transfer from richer locations toward poorer ones.

### 2.1.1 Literature Review

The literature on price-to-rent ratios is ample and I will refer the reader to the literature review of the previous chapter which applies to the current one as well.

The current chapter focuses on the theory side of the discussion and tries to construct a theoretical model capturing both the financial and the relative preference aspects of the price-to-rent ratio in a geographical setting.

The current chapter approach relies on the intuition that any spatial model should capture the local crossing of demand and supply curves, as in Castellanos, Hannon, and Paz-Pardo, [2024](#) and Anenberg and Ringo, [2024](#), and that prices should capture rent as the return of the asset investment, see Vanhapelto, [2022](#). A key fact that a model should capture is that prices are more volatile than rents, as reported by Howard and Liebersohn, [2023](#), Amaral, Dohmen, Kohl, and Schularick, [2023](#) and Hilber and Mense, [2021](#). A key modeling element of the model is employing non-homothetic preferences as theorized by Gaubert and Robert-Nicoud, [2025](#), which implies that location and tenure choices are not independent one from the other.

Following the intuition that local condition influence aggregate effect reported by Fratantoni and Schuh, [2003](#), the current chapter reports that a national monetary shock, in addition to influencing aggregate outcomes, causes a spatial redistribution (equivalent to a regional transfer policy as in Henkel, Seidel, and Suedekum, [2021](#)) of welfare, by reducing spatial inequality.

## 2.2 Theoretical Framework

The aim of this model is to incorporate the double nature of housing in a spatial setting. The model should be able to capture the empirical evidence of the companion chapter and allow us to estimate the heterogeneity in welfare responses to a common mortgage rate shock across tenure choices and space. When considering residential properties, we can associate them to two different prices, the residential price, when the asset is traded on the real estate property market, and the rent, when the asset is traded on the rental market. In the previous section I have highlighted two different interpretations of the ratio between prices and rents: the Classical Gordon Growth Valuation Formula (CGGVF) interpretation and the relative preference one. The former refers to the financial interpretation of residential properties as assets that provide a financial return equal to the stream of rents. In this context, as long as the market are competitive enough, we should expect that prices are equal to the expected stream of rents from the point of view of a buyer. Transposing this to a theoretical formulation and assuming that there might be entities with market powers, I define a Quasi Classical Gordon Growth Valuation Formula (QCGGVF):

$$f((1 + \tau)p) = g(r) \quad (7)$$

Where I indicate a residential property price with  $p$ , the equivalent rent with  $r$ , and the mortgage interest rate as  $\tau$ . I define the rent  $r$  as the entire stream of expected rents. Additionally, I define the two functions  $f((1 + \tau)p)$  and  $g(r)$ , and their derivative  $\partial f((1 + \tau)p)/\partial p > 0$ ,  $\partial g(r)/\partial r > 0$ . Thus, equation 7 shows that the price of a property should be a function of the expected stream of rents and that a positive change in rents should be correlated with a positive change in prices and vice-versa.

The empirical results of the previous sections are not fully consistent with the (Q)CGGVF. On the one hand, we observe a positive correlation between prices and rents responses with respect to a common mortgage rate shift, while on the other hand, we observe both positive and negative responses in the price-to-rent ratios.

The other interpretation of the price-to-rent ratios is the one I refer to as the relative preference interpretation. It relies on the observation that the household that are home-owners are different than those that are renters, the former are richer and older, which tend to self select into different locations. The spatial asymmetry in household distribution, should give rise to different demand curves for rental residential units versus residential properties and, thus, different price-to-rent ratios, everything else equal. The results of the previous chapter, as with the CGGVF interpretation, are not

fully consistent with this interpretation. Taken to the extreme, the relative preference interpretation implies that a relative decrease in the attractiveness of home-ownership across different locations should decrease local demand for home-ownership in favor of local demand for rental properties. If we take these conditions under a single location assumption, we should observe the same outcomes as the literature, where a mortgage rate hike leads to a fall in prices and an increase in rents. The empirical outcomes of the previous chapter describe a positive correlation in price and rent responses to a mortgage rate change, which is against this interpretation in particular a positive price response, and a response of both local population and local share of renters, which is consistent with this interpretation. The results of the empirical chapter are partially consistent with both stories in a complementary manner, suggesting that a theoretical model should be able to capture both.

Given the discussion of the previous paragraph, the second aim of this chapter is to define an Augmented Gordon Growth Valuation Formula (AGGVF) which is able to capture both elements of the standard interpretations of a price-to-rent ratio. In order to stress the emergence of such a formula, and its determinants, from the theoretical perspective I will start by defining a generic set of residential market clearing conditions. Let us suppose there exist  $I$  different locations, indexed by  $i \in \mathcal{I}$ , where  $\mathcal{I} = \{1, \dots, I\}$ , where agents can decide to buy residential properties or to rent them. Additionally, in each location there exist a class of builders which produce the residential asset and provide them on the residential market for price  $p$ . Buyers face a wedge  $\tau$ , which can be read as the mortgage repayments. The supply of rental properties, instead, is provided by a group of intermediaries who buy properties from the builders as an investment and supply them on the rental market for price  $r$ . At this point I do not take any stance on the nature of these intermediaries, thus I suppose there exist both firms and individual home-owners who supply these properties on the rental market. Locations are different based on local wages  $w$  which define both the budget constraints of the households and the labor cost for builders. We assume that the underlying problems are well behaved and that the housing properties can be traded as continuous goods and thus we can define two local market clearing conditions for each location. For simplicity I drop, at the moment, the location index. The first one requires that each property built is traded on the residential property market:

$$H^{supply}(p, w) = H_{firms}^{demand}((1 + \tau)p, r) + H_{households}^{demand}((1 + \tau)p, r, w). \quad (8)$$

Every unit of housing built is either bought by households or by intermediary firms. The second equation implies that every property supplied on the rental market is rented by a household:

$$R_{firms}^{supply}((1 + \tau)p, r) + R_{households}^{supply}((1 + \tau)p, r, w) = R_{households}^{consumption}(r, w). \quad (9)$$

Either firms or individual households supply properties on the rental market, which are then consumed by renters. We can consider two additional identities, one regarding the intermediary firms:

$$H_{firms}^{demand}((1 + \tau)p, r) = R_{firms}^{supply}((1 + \tau)p, r). \quad (10)$$

Which implies that all the residential housing units acquired by these intermediary firms are then supplied on the rental market. In other words, I assume that the intermediary firms do not consume directly any housing unit, but simply provide them to the renters. On the other hand, the home-owners:

$$H_{households}^{demand}((1 + \tau)p, r, w) = H_{households}^{consumption}((1 + \tau)p, w) + R_{households}^{supply}((1 + \tau)p, r, w). \quad (11)$$

Thus, any housing that the households acquire on the property market is either consumed directly or provided on the rental market. Notice that I have assumed that an agent who exclusively consumes housing properties, rather than supplying them on the rental market, should be unbothered by the level of the local rents.

I assume that the underlying problems are well behaved and as such I expect that each demand and consumption curve is increasing in wages and decreasing in own price. The builder supply curve is increasing in price and decreasing in wages (labor production cost), while the intermediary supply curves, either firms or private households, is increasing in rents, and eventually wages, while decreasing in prices.

If we consider the two functions [8](#) and [9](#) separately and we suppose there is an exogenous shock to prices increasing  $p$ . The response in  $r$  in order to balance equation both equations has to be positive. With respect to equation [8](#), an increase in  $r$  would be needed to increase the demand for the real estate property and match the increase in supply. On the other hand, with respect to equation [9](#), an increase in  $r$  would be needed to depress rental properties demand in order to match the increase cost in supplyint these units. Up to these point the two equations are consistent with the (Q)CGGVF interpretation of price-to-rent ratios. Putting together these equations, we get that

$$H^{supply}(p, w) = H_{households}^{consumption}((1 + \tau)p, w) + R_{households}^{consumption}(r, w). \quad (12)$$

Equation [12](#) captures the idea that every unit of housing produced has to be consumed either by home-owners or renters, however these residential properties were supplied to individual households. In this context, an exogenous increase in  $p$  should be associated with a decrease in  $r$  such that, indirectly, the increase in demand for rental properties can match the increase in supply of properties and the decrease in demand for home-ownership. This set of equation, thus, is more consistent with the relative preference interpretation. Thus, the two interpretations have to coexist in any location-tenure choice model, which is an insight consistent with the findings of the empirical chapter.

Models which imply the CGGVF, explain variations in price-to-rent ratios across locations with two possible mechanisms. Higher local price-to-rent ratios imply either lower wedges between the two markets, or higher future expected rents. Once these two forces are accounted, the price-to-rent ratios should be indifferent to other local current factors. This is against the observed facts: price-to-rent ratio not only vary across different locations, but also within the same municipality, where I would expect the same expectations and financial market conditions.<sup>[7](#)</sup> In the OLS regression in table [14](#) I report the coefficients for the OLS regression where the local price-to-rent ratios are regressed on local reported income and local interest rates.<sup>[8](#)</sup> In order to account for local expectations and financial market conditions I include a battery of municipality fixed effects and a battery of time - local labor market fixed effects.

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<sup>7</sup>In the appendix I provide two maps of spatial variation, respectively [11](#) for the variation across different local labor markets and [12](#) for the variation within the municipality of Milan.

<sup>8</sup>Data is collected from the Osservatorio Mercato Immobiliare, a research unit within the Italian Tax Agency, which collects prices and rents from transaction and rental contracts respectively. Outstanding loans mortgage interest rates are collected by the Bank of Italy.

| Price-to-Rent Ratios     |                       |                       |                       |                      |
|--------------------------|-----------------------|-----------------------|-----------------------|----------------------|
|                          | National              | South                 | North                 | Income < Median      |
| Log of Income            | 0.0665***<br>(0.0178) | 0.0814**<br>(0.0354)  | 0.0627***<br>(0.0143) | 0.433***<br>(0.0155) |
| Interest Rates           | -0.0482<br>(0.0296)   | -0.229***<br>(0.0689) | 0.115**<br>(0.0463)   | 0.112***<br>(0.0336) |
| OMI Zone FE              | YES                   | YES                   | YES                   | YES                  |
| Semester $\times$ LLM FE | YES                   | YES                   | YES                   | YES                  |
| N                        | 1'214'365             | 440'599               | 592'882               | 555'942              |
| R-sq                     | 0.765                 | 0.799                 | 0.748                 | 0.804                |

Table 14: The dependent variable is in log terms. A '\*\*' indicates coefficients significant at the 0.1 level. A '\*\*\*' indicates coefficients significant at the 0.05 level. A '\*\*\*\*' indicates coefficients significant at the 0.01 level. Standard errors are reported in parenthesis. Results are robust to local property quality.

As implied by the CGGVF there is a negative correlation between price-to-rent ratios and local mortgage interest rates, but even accounting for local trends, there remains a correlation between local wages and local price-to-rent ratios, which cannot be explained by the standard model.

The aim of the model is to incorporate three forces that have been considered separately by the literature. First, a model has to take into account that prices are positively correlated with rents. This fact follows from the financial interpretation of housing, where rents are the returns of the residential asset, and with the idea that rents capture the underlying cost of the housing good. Second, it has to account for different preferences for owning and renting which should be captured in the ratio between the two tenure choices. Lastly, it has to incorporate the non-tradable nature of housing by incorporating a location choice. The joint presence of these three forces, generates the AGGVF, which accounts for the relative utility preferences.

In order to further analyze the model I will define a specific functional form in order to better define the AGGVF and to run a structural estimation in order to quantify the asymmetric response in welfare to a common mortgage rate shock.

### 2.2.1 The Model

I define a static model where  $Pop \in \mathbb{R}_+$  agents face a simultaneous location-tenure choice. There exists  $I$  different locations indexed by  $i \in \{1, \dots, I\}$  each characterized by a local exogenous wage  $w_i$  and a local supply of residential properties  $H_i^s$  provided by a class of builders. Given that it is not the focus of the current study and the Italian institutional context, I do not allow for the possibility of firm intermediaries between builders and renters.<sup>[9]</sup> Households decide whether to be home-owners or renters. Renters consume housing units  $H_i^c$  and a generic consumption good  $c_i$  that is internationally traded without frictions. Home-owners, face a similar problem to the renter, but additionally they decide the share of housing asset to supply on the rental market  $H_i^r$  and consume the rest. In addition, they have a preference for owned assets, similar to the warm-glow bequest utility in the wealth distribution literature as in Benhabib and Bisin, [2018]. I normalize the generic consumption good price to 1 across each location.

Thus, for a given location choice, the problem of the renter is:

$$\begin{aligned} \text{Max}_{c_i, H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1 - \phi_1) \log H_i^c \\ \text{s.t.} \quad & w_i = r_i H_i^c + c_i \\ & H_i^c, c_i \geq 0 \end{aligned} \tag{13}$$

Where  $0 < \phi_1 < 1$ . The problem of the home-owner, instead, is:

$$\begin{aligned} \text{Max}_{c_i, H_i, H_i^r, H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1 - \phi_1) \log (\mu_i H_i^c) + \beta \log H_i. \\ \text{s.t.} \quad & w_i + r_i H_i^r = (1 + \tau) p_i H_i + c_i. \\ & H_i^c + H_i^r = H_i. \\ & H_i, H_i^r, H_i^c, c \geq 0. \end{aligned} \tag{14}$$

The home-owners, in addition to the consumption allocation between the generic consumption good and the housing good, enjoy a form of utility from owning an asset and enjoy a financial return from supplying housing on the rental market. I assume that home-owners supply properties on the rental market in the same locations where they live. Thus, the model captures the intrinsic dual nature of residential real estate properties, between investment assets and consumption goods.

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<sup>9</sup>The document *Gli Immobili in Italia*, [2023] drafted by the Italian fiscal agency on the state of the Italian residential market reports that 85% of the residential property under rent are provided by individual households rather than firms. As such the choice of dropping intermediary firms is consistent with the Italian institutional context.

Lastly, the cost of a residential property is augmented by a wedge equal to  $1 + \tau$  which can be seen as the additional cost of mortgage loan repayments.

There are two ways in which home-owners enjoy higher utility from housing than the renters. On the one hand, I assume that home owners enjoy a higher utility from each unit of housing by a location specific parameter  $\mu_i$ , which is equivalent, given the functional form to a location specific additional amenity for home-owners. On the other hand, home-owners enjoy utility simply from owning the housing asset, governed by the parameter  $\beta$ . It is possible to rearrange the budget constraint of the home-owner problem such that:

$$\begin{aligned} \text{Max}_{c_i, H_i, H_i^r, H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1 - \phi_1) \log (\mu_i H_i^c) + \beta \log H_i. \\ \text{s.t.} \quad & w_i = ((1 + \tau)p_i - r_i) H_i + r_i H_i^c + c_i. \\ & H_i^c, c_i \geq 0 \quad H_i \geq H_i^c. \end{aligned} \quad (15)$$

Rearranging the budget constraints, rents are equivalent to the cost of housing consumption, equating this aspect between the renter and the home-owner problem. The difference between the housing prices and the rents is equivalent to the cost of the additional utility home-owners enjoy.

The optimal consumption bundle for the rental problem is standard and is:

$$c_{i,renter}^* = \phi_1 w_i, H_{i,renter}^c = \frac{1 - \phi_1}{r_i} w_i. \quad (16)$$

Similarly, the optimal bundle, if internal, of the home-owner is:

$$c_{i,buyer}^* = \frac{\phi_1}{1 + \beta} w_i, H_{i,buyer}^{c*} = \frac{1 - \phi_1}{1 + \beta} \frac{w_i}{r_i}, H_{i,buyer}^* = \frac{\beta}{1 + \beta} \frac{w_i}{(1 + \tau)p_i - r_i}. \quad (17)$$

The problem further allows for the possibility that within a location the rental market does not exist due to a supply market failure. As such I define the condition under which this failure happens, which derives from the asset allocation budget constraint of the home-owners in problem [14](#):

$$(1 + \beta)r_i \geq (1 - \phi_1)(1 + \tau)p_i. \quad (18)$$

The higher the investment return of the asset,  $r_i$ , and the home-ownership additional utility for home-owners,  $\beta$ , the more likely the local rental market exists. On the other hand, the higher the cost of the asset,  $(1 + \tau)p_i$ , and the utility incentive to housing consumption,  $\phi_2$ , the less likely the rental market exists.

The location and tenure choices of the households are further mediated by an idiosyncratic nested Gumbel shock following Rodríguez-Clare, Ulate, and Vásquez, [2022](#). Compared to the standard Gumbel shocks of the literature the nested one allows me to include two different parameters, one for the tenure choice and one for the location one. In particular I define the inverted tenure elasticity as  $\sigma_t$  and the inverted location elasticity as  $\sigma_l$ . The stochastic nature of the two household choices, allows me to define the expected share of agents with a specific tenure choice  $t$ , given a location choice  $i$ , and the expected share of agents in a given location  $i$ . I define the former by  $\lambda_{t|i}$  and the latter as  $\lambda_i$ :

$$\lambda_{t|i} = \frac{\exp U_{t,i}^{\frac{1}{\sigma_t}}}{\sum_{k \in \{buyer, renter\}} \exp U_{k,i}^{\frac{1}{\sigma_t}}}. \quad (19)$$

Similarly:

$$\lambda_i = \frac{\left( \sum_{k \in \{buyer, renter\}} \exp U_{k,i}^{\frac{1}{\sigma_t}} \right)^{\frac{\sigma_t}{\sigma_l}}}{\sum_{j=0}^I \left( \sum_{k \in \{buyer, renter\}} \exp U_{k,j}^{\frac{1}{\sigma_t}} \right)^{\frac{\sigma_t}{\sigma_l}}}. \quad (20)$$

It is then possible to define the share of agents in location  $i$  and tenure choice  $t$ :

$$\lambda_{i,t} = \lambda_i \lambda_{t|i}. \quad (21)$$

As such, the expected share of agents who pick location choice  $i$  and tenure choice  $t$  is a function of the relative utility between home-owners and renters. Due to the non-omothetic preference for home-owners, it follows that a higher local wage implies a higher share of home-owners.

Lastly, we need to define the local builder problem. In each location there exists a competitive building sector where a representative builder supplies housing units. The builder solves by choosing the optimal amount of labor production units,  $n$ , and local land,  $\bar{H}_i^s$ , in order to maximize the profits:

$$Max_n \quad p_i H_i^s - w_i n - \bar{p}_i \bar{H}_i. \quad (22)$$

$$s.t. \quad H_i^s = n_i^\rho \bar{H}_i^{1-\rho_i}. \quad (23)$$

Where  $0 < \rho < 1$ . Builders acquire local land and a set of labor units in order to generate housing units. We define  $\bar{p}_i$  in order to clear the local market of land which is given.  $\rho_i$  is the local technology parameter, the lower it is, the more inelastic the supply of housing is. Taking into

account this equilibrium condition we solve the problem through the zero profit condition. As such the housing units provided by the representative builder is equal to:

$$H_i^s = \left( \frac{\rho_i p_i}{w_i} \right)^{\frac{\rho_i}{1-\rho_i}} \bar{H}_i \quad (24)$$

Having defined all elements of the model, I can now define the equilibrium conditions. I define the equilibrium conditions as a set of prices and rents  $\{p_i, r_i\}_{i \in \{1, \dots, I\}}$  such that:

- Home-owners and renters maximise their respective utility.
- Builders maximise their profits.
- The housing property markets clear in each location.
- The rental markets clear in each location.

In order to simplify notation I define as  $Pop_{i,t}$  as local population in  $i$  who pick tenure choice  $t$ . First I define the equations clearing the market for residential properties:

$$H_i^s = Pop_{i,buyer} \frac{\beta}{1 + \beta} \frac{w_i}{(1 + \tau)p_i - r_i} \quad (25)$$

Secondly, I define the market clearing condition for the rental market:

$$Pop_{i,buyer} \left( \frac{\beta}{1 + \beta} \frac{w_i}{(1 + \tau)p_i - r_i} - \frac{1 - \phi_1}{1 + \beta} \frac{w_i}{r_i} \right) = Pop_{i,renter} \frac{1 - \phi_1}{r_i} w_i \quad (26)$$

The specific functional form chosen, allows me to obtain the following equation:

$$(1 + \tau)p_i = r_i + \frac{w_i}{H_i} \frac{\beta}{1 + \beta} Pop_{i,buyer}. \quad (27)$$

Which is an augmented Gordon Growth Valuation Formula (AGGVF). The consumer price of the residential properties are defined by the stream of rents  $r_i$ , which is consistent with the CGGVF interpretation of price-to-rent ratios, with the addition of an addend that is a function of the local population of buyers. What drives this difference between prices and rents is a direct consequence of the additional utility of home-owners preference for owning asset properties. The different slope of demand curves between owners and renters drives the different impact the two populations have on prices and rent, which is consistent with different demand functions from owners and renters<sup>[10]</sup>

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<sup>10</sup>A different formulation that would drive a similar discrepancy would be to introduce non-linear costs of owning properties. While the additional utility from home-ownership implies that  $p_i > r_i$ , the non-linear costs would imply that  $p_i < r_i$ .

The market clearing conditions can be rearranged to obtain a clearer picture of the local determinants of prices and rents. First, the equation for local prices:

$$(1 + \tau)p_i = \frac{w_i}{H_i^s} \left( (1 - \phi_1)Pop_{i,renter} + \frac{1 - \phi_1 + \beta}{1 + \beta} Pop_{i,buyer} \right) \quad (28)$$

As expected, higher wages and larger local populations, both owners and renters, increase local prices, while a larger local housing availability reduces them. The equation for rents is similar:

$$r_i = \frac{w_i}{H_i^s} \left( (1 - \phi_1)Pop_{i,renter} + \frac{(1 - \phi_1)}{1 + \beta} Pop_{i,buyer} \right) \quad (29)$$

The determinants of local rents are similar to those of local prices, with the asymmetric effect of local home-ownership population on prices and rents. Prices and rents are locally correlated in their responses but the local price-to-rent ratio responses and the relative spatial elasticities depend on the local population distribution. We can further define the price to rent ratio formula for the model.

$$\frac{(1 + \tau)p_i}{r_i} = 1 + \frac{\beta}{(1 - \phi_1)(1 + \beta)} \frac{Pop_{i,buyer}}{(Pop_{i,renter} + \frac{1}{1 + \beta} Pop_{i,buyer})}. \quad (30)$$

Notice that in this context, price-to-rent ratio capture, not only the standard information of the CGGVF, but are also a sufficient statistic for the local relative welfare between home-owners and renters. To better show this relationship, I rearrange equation [30](#), accounting for the fact that  $Pop_{t,i} = \lambda_i \lambda_{t|i} Pop$ :

$$\frac{(1 + \tau)p_i}{r_i} = 1 + \frac{\beta}{(1 - \phi_1)(1 + \beta)} \frac{1}{(\lambda_{renter|i}/\lambda_{buyer|i} + \frac{1}{1 + \beta})}. \quad (31)$$

Given that the local share for a given tenure choice is a function of the local utility of home-owners and renters. It follows that the price-to-rent ratio is a sufficient statistic for relative welfare of renters with respect to home-owners. Given that locations with higher wages are more likely, in the model, to be home-owners, the model is consistent with the facts reported in table [14](#).

## 2.3 Structural Estimation

The results of the empirical section, imply that prices and rents react to a common mortgage rate shock in a geographical asymmetric manner. In particular locations with higher income tend to

observe higher price, rent, and share of renters responses, while observing lower population ones.<sup>11</sup> This asymmetric response suggests that households in different locations might receive different welfare shocks from an exogenous mortgage rate shock. If this is the case, then any policy that affects the national residential property market, has to take into account the possibility that there are relative spatial welfare transfers.

In order to test this hypothesis I will calibrate the model considering the mortgage rate hikes that happened across the developed countries in the years 2021 and 2023. As I show in graph 7, the increase in mortgage rates, while not to their all time high, was fast enough to rattle households and governments. It is realistic, then, to expect that such an increase to have lead households to change their previous behaviors. Additionally, the graph highlights, that while different locations have different mortgage interest rates, the direction of the local trends are similar across locations and in particular for the period after 2015. Thus, the mortgage rate increase under scrutiny is tantamount to a national mortgage rate shock.

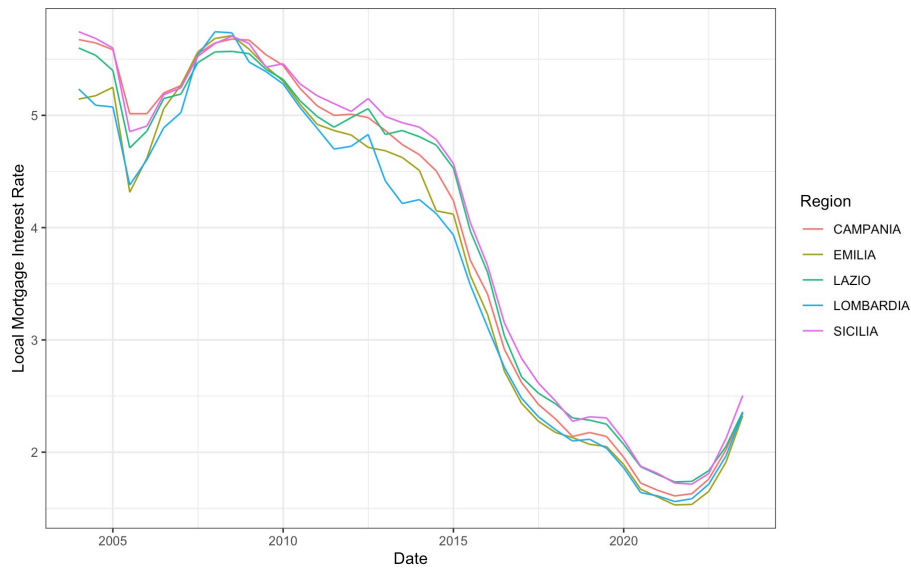


Figure 7: The graph reports the local mortgage rates between 2004 and 2023 in Italy across five different regions covering most of the Italian population: Lombardia, Emilia-Romagna, Lazio, Sicilia, and Campania.

The objective of the estimation is, thus, to test that a sizable mortgage rate shock has an

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<sup>11</sup>In the additional results provided in the appendix I also observe a larger price-to-rent ratio responses in richer locations.

asymmetric spatial effect on both prices and rents and, furthermore, on the welfare of households. Given the simplicity of the model, I will not expect to correctly estimate the levels of the welfare and the responses of the variables of interest, rather at how wide is the distribution of these estimates across locations.

### 2.3.1 Targeted Parameters

Before estimating the parameters of interest I rearrange the model, in order to better estimate  $\mu_i$  as a location specific home-owner amenity. Thus the utility of a home-owner agent given the choice of location  $i$  is:

$$U(i, buyer) = \log A_i + \log A_{i,buyer} + \phi_1 \log c_i + (1 - \phi_1) \log H_i^c + \beta \log H_i$$

I set  $A_i = 1$  for  $i = \text{Padova}$ . I select four hundreds and twenty locations, four hundreds of which are local labor markets, while the twenty remaining are defined as the residual municipalities grouped by administrative region. I pick the four hundreds local labor market by picking the LLM associated to the administrative capital of each region and the remaining ones by picking those associated to the one hundred and eighty most populous remaining municipalities and the two hundreds less populous ones. I report the map of the selected locations in figure [8](#).



Figure 8: The map reports the 420 different locations of the structural model. In red I highlight the 400 local labor markets, while the area in white are aggregated along their administrative region.

I estimate four preference parameters that are common to each location. Two of these are the preference weights of the household of the different types of consumption:  $\phi_1$  is the parameter for the generic consumption good and  $\beta$  is the parameter associated to the intrinsic utility a home-owner draws simply from owning the asset. The remaining two parameters, are the Gumbel parameters  $\sigma_t$  and  $\sigma_l$ , respectively the parameter for the Gumbel preference shock associated to the tenure choice and the location choice.

The remaining variables to be estimated are location specific: the location amenities  $A_i$ , the local home-ownership amenities  $A_{i,buyer}$ , the local land availability  $\bar{H}_i$  and the local parameter governing the local construction technology  $\rho_i$ . Local wages, local consumption prices, and local mortgage interest rates are taken as given by considering population weighted LLM average. Local residential supply and population are taken as the sum of the local municipal supplies and residents by LLM.

### 2.3.2 Algorithm

I will now describe the algorithm used to estimate the parameters. I will focus on the observations of year 2014. The first step is to estimate from the data the parameters  $\phi_1$  and  $\phi_2$ . As it is standard in

the literature, I recover these two parameters through the share of expenditure of renters on housing.

I now set an outer shell, by guessing a value for  $\beta$ ,  $\sigma_t$ , and  $\sigma_l$ . Having these values it is possible to recover exactly the values of  $p_i$  and  $r_i$  through the two local market clearing conditions for every location. I can then invert the model extracting the amenities in order to match the local tenure choice shares and population shares. The specific functional form I adopted allows me to estimate the two sets of amenities separately. First, I revert the local home-ownership amenities by inverting the local share of renters

$$\lambda_{r|i} = \frac{\exp(\ln A_i + u_{i,r})^{1/\sigma_t}}{\exp(\ln A_i + u_{i,r})^{1/\sigma_t} + \exp(\ln A_i + \ln A_{i,b} + u_{i,b})^{1/\sigma_t}}$$

Rearranging the equation and simplifying equation, it is possible to obtain

$$A_{i,b} = \exp \left( \ln \left( \frac{\exp(\ln A_i + u_{i,r})^{1/\sigma_t}}{\lambda_{r|i}} - \exp(\ln A_i + u_{i,r})^{1/\sigma_t} \right)^{\sigma_t} - \ln A_i - u_{i,b} \right)$$

Due to the log-linear form of the optimized utility, as shown in the theoretical section, and due to the properties of logarithms and exponential it is possible to rearrange the above equation in order to simplify  $A_i$  canceling it. Thus, I am able to retrieve  $A_{i,b}$  without having estimated  $A_i$ . Finally I conclude the static part of the inner shell, by retrieving the local amenities  $A_i$  in order to match the initial distribution of the population.<sup>[12]</sup>

Having measured the local prices and rents and the local amenities, it is possible now to perturbate the model. As such, I increase the local interest rates by 1% and I recover the local elasticity of supply by matching the local price elasticities with the ones measured through SSIV as in the empirical section by restricting the sample to each LLM.<sup>[13]</sup> Having now recovered the supply after the perturbation it is possible to recover  $\rho_i$  and  $\bar{H}_i$ . Defining  $H'_i$  and  $p'_i$  as the outcomes of the perturbed model, I can exploit the <sup>[24]</sup> to isolate  $\rho_i$ . To do so I consider

$$\frac{H'_i}{H_i} = \left( \frac{p'_i}{p_i} \right)^{\frac{\rho_i}{1-\rho_i}}$$

Applying the logarithm function to both side, I am able to recover the local value of  $\rho_i$ , where I restrict, if necessary, its value to  $0 \leq \rho_i < 1$ . Having computed  $\rho_i$  for all locations I can recover  $\bar{H}_i$ .

Once the inner shell is computed it is possible to estimate the objective value for the outer shell. I aim to minimize

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<sup>12</sup>As stated before I set Padova to be the reference LLM, setting  $A_{Padova}=1$ .

<sup>13</sup>The distribution of the results is reported in the appendix.

$$\sum_x \left( \sum_i |\varepsilon_i^x| - \sum_i |\epsilon_i^x| \right) \quad (32)$$

Where I indicate with  $\epsilon_i^x$  the empirically estimated elasticity of the variable  $x$  with respect to local mortgage interest rates in location  $i$ . Where the target elasticities are obtained by running the SSIV estimation as in the empirical section with a restricted sample for each LLM. Similarly, I indicate with  $\varepsilon_i^x$  the structurally estimated elasticity of the variable  $x$  with respect to local mortgage interest rates in location  $i$ . The set of variables indicated with  $x$  is local rents, local population and local share of renters. Given that the outer shell aims to estimate three global parameters, I aim to match the average size of the local responses.

Having estimated all the parameters, it is possible to run the counterfactual of the 2021-2023 mortgage interest rate hikes. To do so, I estimate the local amenities for the year 2021 in similar manner to the 2014 estimation, in order to capture local trends. Additionally I recover the local  $\bar{H}_i$  from the [\[24\]](#). I then compute local prices and rents with the local 2023 interest rates.

Summarizing the algorithm:

- Recover  $\phi_1$  and  $\phi_2$  from the observed shares of expenditures on housing paid by renters.
- Set the outer shell by guessing  $\beta$ ,  $\sigma_l$  and  $\sigma_t$ .
  - Set the inner shell by solving the problem for the year 2014 by computing local prices and rents with the guessed parameters.
  - Retrieve  $A_i$  and  $A_{i,b}$  by matching local tenure choice shares and local population shares.
  - Perturbate the model by increasing  $\tau_i$  by 1%.
  - Retrieve the supply elasticities by matching the local price elasticities.
  - Retrieve  $\rho_i$  and  $\bar{H}_i$  through the computed supply elasticities.
- Iterate the inner shell in order to select  $\beta$ ,  $\sigma_l$  and  $\sigma_t$  to minimize the objective function.
- Solve the problem for the year 2021 by computing local prices and rents, with the computed parameters.
- Retrieve  $A_i$ ,  $A_{i,b}$ , and  $\bar{H}_i$  by matching local tenure choice shares, local population shares, and local housing supplies.

- Run the counterfactual by setting the mortgage interest rates observed in 2023 and solving the model by computing prices, rents, population tenure and location distributions and the respective welfare.

### 2.3.3 Estimation

Having run the algorithm described in the previous section it is now possible to state the estimated parameters and the variation of the variables of interest after a mortgage rate shock comparable to the one observed between 2021 and 2023.

The overall objective is to test whether the model is able to capture the asymmetric responses of prices, rents, location, and tenure choices that I have observed in the empirical section of the paper. The second order objective is to test whether there is an asymmetric response in welfare as well. Given the simplicity of the model, I do not expect to match exactly the elasticities estimated in the empirical section of the paper. The aim of this structural exercise is to observe a spread in the counterfactual responses positively correlated with the local wages.

First let me state the estimated global variables. I report the results in table [15](#).

| Parameter  | Estimation |
|------------|------------|
| $\beta$    | 0.0074     |
| $\sigma_t$ | 4.011      |
| $\sigma_l$ | 24.973     |

Table 15: In the table I report the estimated global variables.  $\beta$  is associated to the home-ownership value for households.  $\sigma_t$  and  $\sigma_l$  are the two Gumbel distribution parameters, the first associated with the tenure choice of households, while the second is associated with the location choice.

Before delving into the estimated responses, given that I recover prices and rents from the model, it is important to test whether the market clearing conditions generate a vector of prices and a vector of rents that are consistent with those observed. It is important to keep in mind that the prices and rents generated by the model are drawn from a simple single period environment. Given that yearly wages are taken as exogenous, one way to think about the model generated price and rents is that these are normalized to a one-year time horizon, centered around the current yearly wages and current available supply. What the model is currently unable to capture is the dynamic nature of housing choices and the local future expectations as seen, for instance, in Vanhapelto, [2022](#)<sup>[14](#)</sup>

<sup>14</sup>The main objective of the present paper is not to solve the dimensionality issue affecting dynamic spatial models

Additionally, prices capture the home-ownership cost associated with a real estate property. I report in table [16](#) the correlation between the model generated prices and rents and the observed ones for both years 2014 and 2021.

| Year | Price correlation | Rent correlation |
|------|-------------------|------------------|
| 2014 | 0.217             | 0.319            |
| 2021 | 0.193             | 0.361            |

Table 16: In the table I report the correlation between the model generated vectors of prices and rents and the observed ones for both 2014 and 2021. The prices and rents generated by the model are thus consistent with the observed distribution of prices and rents.

The model is able to generate realistic distributions of both prices and rents, as indicated by the positive sign of the correlation between the model generated prices and rents and the observed ones. As highlighted before, the correlation is not perfectly 1 as the simplification of the model ignores important aspects of the residential markets, such as dynamic life cycle aspects or expectations.

The next step would be to compare the results of the empirical section with the elasticities estimated in the counterfactual of the structural exercise. In particular, I will report the correlations between the estimated elasticities and the 2021 observed wages. Given the results of the empirical section, I expect a positive correlation between local wages and the responses of prices, rents, and local share of renters and a negative one with respect to population responses. I report a summary of the correlations in table [17](#).

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with capital accumulation. It is important to stress, though, that finding novel ways to solve the need of having agents accumulating their own capital, both mobile and immobile, while optimizing their lifetime location trajectory is a necessary step for better capturing the interactions between rental and home-ownership markets.

| Variable         | Correlation |
|------------------|-------------|
| Price            | 0.052       |
| Rent             | 0.110       |
| Price-to-Rent    | −0.145      |
| Population       | −0.221      |
| Share of Renters | 0.059       |

Table 17: In the table I report the correlation between the model generated elasticities with respect to local mortgage rates and the local wages. Given the result of the empirical section, I would expect the correlations of price, rent, and share of renters responses to be positive. On the other hand, I expect the correlation of population responses to be negative. The model is able to recreate the estimated correlations. In addition, the model predicts a negative correlation between the price-to-rent ratio, including the mortgage interest rates, and the local wages.

An additional confirmation of the results, is that the elasticities of prices and rents are positively correlated, which is consistent with the financial aspect of the AGGVF described in the previous sections of the paper.

Lastly, I report the welfare responses of the counterfactual. While this structural exercise does not have the pretense of being a full welfare analysis due to the simplicity of the model, it is still valuable to explore the utility responses to a mortgage hike in order to observe the distribution of responses and to validate the model. First, I observe that both the aggregate utility for buyers and renters fall, with a larger proportional fall for the renters. Second, I report the correlation between the utility responses with the local wages in table 18.

| Variable           | Correlation |
|--------------------|-------------|
| Home-Owner Welfare | −0.105      |
| Renter Welfare     | −0.179      |

Table 18: In the table I report the correlation between the model generated elasticities of local welfare with respect to local mortgage rates and the local wages.

The preliminary evidence of this structural exercise suggests that a mortgage rate hike has consequences for both home-owners and renters. In particular, the lion share of the utility hit is passed through to renters, through higher rents, which attenuates the effect of higher mortgage interest rates on home-owners. On the other hand, a national mortgage rate hike reduces the spatial

inequalities through residential consumption. This spatial effect is consistent with the Howard and Liebersohn, [2023](#) paper and their line of research, even though in their paper it is a consequence of construction elasticity, which is not the case in the present structural exercise.<sup>[15](#)</sup>

### 2.3.4 Interpretation of the Structural Estimates

The objective of the present structural exercise was twofold. First, I am interested in validating whether a stripped down spatial model with tenure choice was able to recreate, at least with respect to prices and rents, the responses to a common mortgage interest rate shocks. The second objective was to recover a preliminary evidence on the potential spatial welfare distribution consequences of such a model.

Consistently with the empirical estimation, the responses of both prices and rents to a positive mortgage rate hike are positively correlated with the local wages. In the same manner I observe a positive correlation between the response in the share of renters and the local wages. Overall, the model is able to recreate the empirical results of the paper, implying that the joint location-tenure choice in a household-landlord environment is able to provide a sound basis for a structural model which aims to recreate the complex dynamics between geography and the residential real estate market.

The second objective was to compute the distribution of the local welfare responses and to gather a preliminary result regarding the impact of a national mortgage rate shock on the spatial welfare inequality. We can draw two conclusions, in this regard, with respect to the welfare distribution. First, I observe a larger percentage fall in the national utility of buyers than the one of renters. Second, I observe a larger fall in utility for both buyers and renters in richer locations than poorer ones. Overall, the model predicts two inequality consequences of a mortgage interest rate hike. On the one hand, it decreases the inequality between home-owners, who can offset partially the impact of higher property prices through higher rents, and renters.<sup>[16](#)</sup> On the other hand, the spatial inequality is reduced, as agents reallocate across different locations due to an asymmetric response in both prices and rents.

This structural exercise opens a set of research paths in order to further deepen and understand the complex interactions between households tenure choices and their location choices. A first step would be to provide a dynamic model, which would allow me to capture the dynamic interactions

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<sup>15</sup>The estimated correlation between  $\rho_i$  and the local wage is positive in the present research.

<sup>16</sup>Notice that this effect would be amplified if home-owners care not only about the ownership of a residential property in itself, but care also about the expected future asset price.

between rental properties and owner-occupied ones. Additionally, introducing the heterogeneity of agents would allow to further study the interaction between age and the residential ladder, which would be captured in the AGGVF.<sup>17</sup> A further building block of an augmented model is the construction side of the market, which is simply sketched in the present model, but is key in generating the asymmetric results observed in the empirical section. Lastly, the model focuses in the interaction between different locations in different local labor markets and not in the interaction between locations within a local labor market. We observe in the exercise a movement of agents toward poorer local labor markets, but I am not capturing the within local labor market movements.

## 2.4 Conclusion

The present chapter expands on the results of the previous empirical one. The aim of the chapter was to define a spatial model with tenure choice such that I am able to capture both the financial interpretation of price-to-rent ratios, where the price is simply the future stream of rents, and the relative preference interpretation, which captures the local asymmetric demand for home-ownership and rental properties.

I construct a static model where agents decide where to locate and their tenure. The model has a few additional elements with respect to a standard spatial model: home-owners supply part of their residential properties on the rental market and derive utility not only from consuming housing but also from owning it. The market clearing conditions, thus, imply that rents are determined by local housing supply, local wages, and both the population of renters, and, in a smaller proportion, the population of owners. The prices, instead, are equal to rents, as the financial interpretation theorizes, and to an additional element tied to wages, the supply, and the home-owner population.

In order to test the model I run a counterfactual simulating the sudden increase in mortgage interest rates between 2021 and 2023 in Italy. The counterfactual matches the insights drawn from the previous empirical chapter with respect to the asymmetric spatial responses in prices, rents, price-to-rent ratios, location, and tenure choices. It also suggests that a national mortgage rate hike would affect local welfare unequally, implying a transfer of welfare from renters in favor of home-owners and from richer locations to poorer ones. The current paper adds to the literature trying to understand the price-to-rent ratios, suggesting that any realistic modelization of price-to-rent ratios has to take into account both the financial and the relative preference interpretation of the price-to-rent ratios. Furthermore I argue that any model trying to capture how prices and rents

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<sup>17</sup>I provide in the appendix a simple model for both.

interact with the wider economic context should take into account the geographic dimension of the residential market and a realistic theory of how rental properties are supplied on the rental market. Further research can enrich the baseline model I defined in this chapter in order to better capture the interaction between the economy and the residential market and the spatial redistribution effect of any housing access policy.

### 3 Chapter 3: Property Taxation and Real Estate Price Dispersion

#### Abstract

I test the claim that property taxes reduce the price dispersion across properties of different quality thus reducing wealth inequality. I exploit the removal of the Italian property tax on main residences and its design to identify the effect of such tax on property prices. The results are consistent with the previous claims but heterogeneous in magnitude across different property markets. Additionally, I design a monocentric city model to connect the real estate asset literature with the urban economics one, and I find that the former has been ignoring two channels for the property tax to affect prices: the ability of households to switch between properties of different quality and its effect on the local consumption good bundle price.

**JEL codes:** G12, H24, R21, R31, R38

#### 3.1 Introduction

Fiscal policy is one of the most important avenues for research in economics and one of the most contested state tools in the political competition of any country. Local jurisdictions are often funded in the West through real estate taxes, but the academic debate regarding this type of taxation revolves around the same questions since the 1970s without any convincing evidence in either direction. On a theoretical side the debate revolves around who bears the cost of the tax, whether homeowners or capital owners providing the land. The models adopted revolve around real estate as assets and a common result is that in mixed communities, where there are housing properties with different quality levels, the price dispersion is reduced. On the empirical side, most published research tries to disentangle the already cited question regarding real estate taxation with reduced forms methods.

The objective of the chapter is twofold. On the empirical side the aim is to explore the claim set out by the seminal paper by Hamilton (1976) and reaffirmed by Zodrow (2014) that one of the consequences of the property tax is to reduce the price dispersion due to unobservables. I will follow previous research adopting reduced form methods, but I will focus on the specific design of the Italian real estate tax. Spatially, the tax provides a fiscal incidence variation across local jurisdictions. While on the dynamic side, the Italian real estate taxation policy went through a series of design changes which changed the pool of properties affected between 2006 and 2013. The two provide a combination of temporal and spatial variation across the Italian real estate properties

with two important consequences. On the one hand it will enable me to avoid the endogenous political choice of the local tax rate. Even if a municipal administration adjusts the tax rate to respond to the national policy, they cannot impose different tax rates in different locations within the city. On the other hand, the two together provide an exogenous policy variation across the country which I will be able to exploit to identify the specific effect of the Italian property tax and its partial removal. An additional novelty with respect to the previous literature is the data I use. The Italian fiscal agency provides aggregate data on the minimum and maximum prices and rents for several types of real estate properties between 2002 and 2020 biannually in small homogeneous areas. As such I am able to abstract from local characteristics influencing the price of a property, while controlling for the general quality of the construction and the relative location with respect to the city. A further characteristic is that the data includes all the information the fiscal agency is able to observe, thus leaving the remaining price variations to unobservable characteristics.

On the theoretical side the objective is to provide a bridge between the real estate asset literature, from which the previous theoretical research stems from, and the urban economics literature. The present work, while being a starting point for future research, highlights two novel channels through which the property tax influences local property markets that were ignored before. First, the model will allow for agents to switch between different housing qualities. Previous works on mixed communities assumed that agents were intrinsically interested in one or the other and the provision of the different real estate properties competed for the same land. Second it will highlight the importance of the effect of a variation in the fiscal incidence on the price of a consumption good bundle.

While the empirical results confirm the prediction of previous research, the theoretical side of this paper will provide a more complicated picture than the one put forward by the previous work of both Hamilton and Zodrow. The empirical results provide evidence that a property tax does indeed reduce the price dispersion of the local property markets, even though the size of the effect seems to vary across different jurisdictions. This paper will also provide evidence of general equilibrium effects regarding other real estate property prices, such as those of offices and shops, but not on rents which were not affected by the policy changes. Theoretically, introducing the possibility of agents to switch between different type of housing and the possibility of the consumption good bundle price to adjust to the consumption choices of the households, implies that the direction on the price dispersion of the property tax is not as defined as in previous models. While further empirical research is needed to test these novel implications, it is possible that this result is tied with the

unexplained variation of the empirical results across the different jurisdictions considered.

### 3.2 Literature Review

The literature on the incidence of property taxation is old with several questions unresolved. Since the 70's the debate has been between three views: the benefit view, a follow up of the Tiebout (1956) model as articulated by Hamilton (1975) and Hamilton (1976), the capital-tax view, as articulated by Mieszkowski (1972) and extended theoretically by Zodrow (2014), and the traditional view, which dates back to Simon (1943). The main debate revolves around the question of who bears the cost of a property tax, the capital owner or the resident, and the mechanism behind it.

Given that the traditional view has been incorporated as a limit case in the capital-tax view, I will follow the recent literature (as in Oates and Fischel (2016)) and focus on the other two. A good review can be found in Zodrow (2001). The benefit view sees property taxes as a public good fee. Following the insight of Tiebout (1956), residents receive back their public spending in form of public goods. In this framework, given enough tax-benefit menus available, residents 'shop around' jurisdictions for their preferred combination. Succinctly put, the property tax is fully capitalized into prices and is non-distortionary. The capital-tax view, instead, argues that local deviations from the average national property tax distort the allocation of capital across jurisdictions. These deviations act as an excise tax and thus the capitalization is not full and the tax has a progressive albeit distortionary view. The traditional view is captured by the capital-tax view as the former focuses with a partial equilibrium approach on the deviations, while the latter follows Harberger (1962) and sets up a general equilibrium framework.

From a theoretical point of view most papers focus on the question of horizontal equity, thus studying whether property taxes create distortions across different jurisdictions. The trade off for the simplicity of the model is that each jurisdiction is captured by a single housing price and thus provides an incomplete view of the housing market. Two exception that focus on vertical equity implications of a property tax: Hamilton (1976) for the benefit view and Zodrow (2014) for the capital-tax view. Hamilton (1976) extends his own Hamilton (1975) paper in the case of mixed communities. The main finding is that the benefit tax view is preserved but higher value homes capitalize a discount, with respect to a perfectly segregated community, as they are overpaying the common public goods, while lower value homes are traded with a premium as the prices capture the fact that they are contributing less to the common public goods. Zodrow (2014) finds similar result with a capital-tax view approach. These models have one flaw, first they do not allow for agents

to move across different housing goods. There exist two types of agents,  $h$  and  $l$ , which consume respectively  $H^h$  and  $H^l$ , but they are not allowed to move between one and the other due to changes in relative prices.

There are two different theoretical approaches to modelling the housing market with a more realistic perspective. On the one hand, economists have tried to model the spatial characteristic of a city by modeling the endogenous choices of the inhabitants. The simplest model is the one by Alonso (1964), Muth (1969), and Mills (1967) and formalised by Wheaton (1974), where cities are described by a single central business district where each agent works. Residential rents emerge by internalizing the increasing transportation costs for commuting. More recent models capture a more rich environment, by having agents choosing endogenously where to work and where to live. I report the seminal paper by Ahlfeldt et al. (2015) and the more general theoretical survey of the class of models by Redding and Rossi-Hansberg (2017).

The second theoretical approach tries to better capture the frictions involved in the housing market through search and match models. I refer, as an example of the literature, to Genesove and Han (2012) and Carrillo (2012).

On the empirical side, most research tries to answer one of the two questions: what is the degree of capitalization of the property tax in the housing prices and how do different policies and frictions affect property prices. Most studies adopt a reduced form approach in order to capture the effect of the property tax on capitalization. There are two issues that different identification strategies attempt to work around. On the one hand, there is the issue of spurious correlation between property prices, property taxes and public good provision. The empirical issue has been around since the study of Oates (1969) as surveyed by Palmon and Smith (1998), both of which argue that the data is consistent with a full capitalization of the property tax through a Hamilton-Tiebout mechanism. Oliviero and Scognamiglio (2019) focuses on the same institutional setting of the the present paper from a political economy angle. They find that Italian municipalities have a higher probability to react to the possibility of adjusting the property tax rate based on the proximity of a local election. Municipalities that respond in such a manner are more inefficient and have lower social trust. Additionally, Italian properties react to the variation in property taxation, an evidence that there is some capitalization in the Italian setting, despite the complexity of the computation of the tax. The identification strategy of the current study will avoid this endogeneity by focusing on within-city variation in taxes. In the American setting, both Bradbury, Mayer, and Case (2001) and Lang and Jian (2004) exploit the introduction of a constraint on spending in Massachusetts to

study the capitalization of property taxes and public goods. While the former finds that constrained communities were able to increase their public spending due to an increase in property values and, thus, in local revenues and that public spending did not affect property prices, contradicting the Hamilton-Tiebout mechanism, the latter study finds that the constraint reduced property values and communities that were able to increase public spending more in the subsequent years enjoyed higher property prices. Lang and Jian (2004) argue that the issue with Bradbury et al. (2001) is that the latter considered public spending as exogenous and not endogenously set by the lawmakers. Giertz, Ramezani, and Beron (2021) study the capitalization of the property tax in Dallas county exploiting a variation in tax rates across jurisdiction through a DiD approach with administrative data. They cannot reject the hypothesis of full capitalization and find that urban taxes have higher degree of capitalization. The result is consistent with the argument, set forth by Lutz (2015) and Oates and Fischel (2016), that the benefit view is more consistent with urban environments, where there is less availability of land, while the capital-tax view applies more to suburban environments.

The second issue that arises regards the complicated nature of the taxation schemes and the ability of agents to, firstly, navigate the different fiscal requirements, and second, the degree to which homeowners and homebuyers are able to account for future property taxes. While previously cited studies, such as Oliviero and Scognamiglio (2019), do suggest that, at least partially, prices account for variation in property taxes, it is a warranted question. Along this line of research de Bartolomé and Rosenthal (1999) suggests that ninety percent of previously adopted property tax capitalization equations were misspecified. Bradley (2017) finds that homebuyers are inattentive to fiscal obligations and overpay properties up to \$10000 for the average house. This is consistent with the Cabral and Hoxby (2012) which argue that the method of payment of the property tax changes the salience of the tax. Additionally, Wasi and White (2005) find that, based on the specific rules regulating reassessment of properties for fiscal purposes, there might be additional non-price consequences. Lastly, regarding non-price responses, Bradley (2018) finds that experienced estate-brokers concentrate the transactions before the mandated routine property value reassessments.

Given that property taxes are often the main direct fiscal revenue source for local administration, there is a wide literature in public finance that intersects with the topic at study in this paper. Lutz (2008) and Lutz, Molloy, and Shan (2011) find that local municipalities respond to variations of prices on the housing market when setting the property tax rate. The lag is explained by institutional features of the property tax and by delays in assessments. An additional set of papers focus on different types of property taxation, focusing on transaction and acquisition-value ones.

Both O’Sullivan, Sexton, and Sheffrin (1995) and Best and Kleven (2018) find that the transaction value tax has strong distortionary effects and Kopczuk and Munroe (2015) finds further evidence that when notches in the fiscal framework are introduced there is an additional risk of the market unraveling above these thresholds. Regarding acquisition-value taxes both O’Sullivan et al. (1995) and Wasi and White (2005) find that mobility is reduced as home-owners tend to stay in their properties longer than in other jurisdictions in order to reap the increasingly favourable market value on taxation ratio.

Shifting the focus of property taxes from property prices to rents, the question is whether renters shift part of the cost of a property tax to tenants. Both Hyman and Pasour (1973) and Löffler and Siegloch (2021) find that differences in property taxation are shifted forward to tenants. The latter study, in particular, points out that an increase in property taxes leads to an initial partial pass-through, which increases to a full pass-through in the following years. Dusansky, Ingber, and Karatjas (1981) tries to combine in a single econometric model both renters and homeowners and finds a partial capitalization of a property tax, partial pass-through of the tax to renters, and association of higher rental units with lower property prices. Additionally, they argue that actual rental values are a bad proxy for housing prices, suggesting that the two have to be considered as separate markets with different frictions<sup>18</sup>

The last strand of literature related to the current study is the one related to wealth taxation. Real estate is one of the few widely taxed assets in Western countries and thus we can try to infer some potential effects of taxation on capital supply. Following the limitations of Jakobsen, Jakobsen, Kleven, and Zucman (2020), tying these strands of literature can provide several benefits. First, it is possible to study a widely distributed asset, such as real estate, and the effect of a property tax on the forward-looking behaviour of those aspiring to own a property<sup>19</sup>. Second, given the institutional setting of the present study it is possible to study shifts between different allocation of capital, thus capturing more general equilibrium effects of property taxation. On the one hand, we have house ownership versus renting, capturing the saving nature of real estate. On the other hand, we can study the supply of capital between residential ownership, ownership with the intention of renting, and urban real estate as an input for production<sup>20</sup>. It is also important to point out that, while real estate capital is still exposed to capital mobility, in particular high-value business projects, the widespread ownership of housing wealth relative to other types of assets reduces the

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<sup>18</sup>Instead of assuming property prices as the present value of the stream of rents.

<sup>19</sup>Such as the rent versus buying question.

<sup>20</sup>I.e. offices and shops

risk of international movement among the wealthy and the risk of sampling a reduced pool of super-wealthy. Furthermore, excluding a set of policy papers such as OECD (2018) and McDonnell (2013) both of which do not focus on the specific issue at hand, it is the first paper to my knowledge tying the construction of a wealth tax policy and the issue of value assessment.

### 3.3 Institutional Setting: The Italian Property Taxes

The current framework of the Italian property taxation was first implemented in 1992 with the Imposta Straordinaria sugli Immobili (ISI) set up by the Amato government through an emergency financial law. The tax was soon transformed in the Imposta Comunale sugli Immobili (ICI) which was first collected in 1993.

The Italian property taxation is designed as an assessed value framework and the revenue is mostly earmarked for municipal jurisdiction.<sup>21</sup> Given that a real estate property is not continuously traded on the market and thus it is not possible to estimate every year the correct market price, the state relies on a small set of observables to construct an assessed value and compute the tax based on such value. The explanation of the tax will be structured in two parts, in the first one I will explain the framework of the tax which has remained stable in its key element across the past thirty years, while in the second one I will explain the changes that have happened across the years, in particular under the fourth Berlusconi government in 2008, under the Monti government in 2011, and under the Letta government in 2014. These changes will be the heart of the identification strategy regarding the temporal variation. Additionally I will restrict the analysis to residential properties, which will be the main subject of the study, in order not to burden this section more than the necessary.

In order to compute the amount owed to the state for residential property a set of information regarding the observables is needed: the location of the property and the corresponding *tariffa d'estimo*, the category and class, the number of *vani*<sup>22</sup>, and the municipal tax rate. I will explain each one of the elements and provide an example.

- **Location:** The location is one of the two main observables evaluated by the state. In 1950 the Italian state was divided in different relatively homogeneous areas in order to create the new postwar cadastre. These areas coincide most of the times with the area of a specific municipal jurisdiction, but larger centers are divided in more than one homogeneous area, which I will

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<sup>21</sup>With the exclusion of a specific set of special properties such as industrial complexes, which tax revenue is earmarked directly to the central government.

<sup>22</sup>Singular *vano*, plural *vani*

refer to as *Zone Censuarie* (ZC).<sup>23</sup> For each category and class of residential property, the state provides a *tariffa d'estimo* (estimated price) for each *vano*.

- **Category and Class:** Every property in Italy has to be registered with the state at the cadastre which assigns a category, based on the usage of the property and its quality, and a class, which refers to local quality within a class. In particular the category registers the usage (i.e. *A* for residential building, *B* for buildings of public interest such as religious buildings and public libraries) and the general quality (i.e. *A/2* indicates the civilian residences and *A/9* indicates castles and historical palaces). The class range varies between *zone censuarie* and tries to capture the relative quality of a property relative to others of the same category and location.
- **Number of Vani:** the size of a residential property is not assessed specifically by size but in terms of the number of useful rooms (*vani*) it has. In particular, living rooms, bedrooms, and furnished kitchens are considered *vani*, but not restrooms. There are further specific rules but they apply to specifically large rooms which are rarely the case and thus I will ignore them for the sake of simplicity.
- **Municipal Tax Rate:** Given that property taxation is the main source of revenue of the municipal authorities, the local councils are allowed to set the tax rate within a nationally specified boundary.

It is important to specify that the Italian cadastre assessment of the properties are rarely fully reflective of the true market price of a property. There are two reasons for this: first, local amenities change. The *tariffe d'estimo* were set between 1991 and 1994 and most cities have evolved in the mean time. Additionally the *zone censuarie* were set in the 1950 and are not able to capture more local changes in amenities.<sup>24</sup> Second, people rarely re-register their houses after a renovations and there is no required law for re-assessment by the cadastre at any specified point in time. Thus the category and class of a property reflect out of date assessments. While this is not usually the case for important renovations, such that the general class changes (i.e. from category *A*, residential properties, to *D*, mainly properties with industrial destination), it is much more salient for smaller

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<sup>23</sup>Milan, for example, is divided into three areas as I show in the appendix.

<sup>24</sup>Consider the Isola and CityLife neighborhoods of Milan which underwent important renovation efforts between 2004 and today appreciating in the mean time relative to the rest of the city. The corresponding *tariffe d'estimo* are definitely not able to capture these changes.

changes (i.e. consider renovations between properties of categories A/2 to A/5, which encompasses macro qualities such as civilian properties to 'ultra-demotic' properties). An extreme assumption is that the tax is so out of date with respect to residential houses, that within *zona censuaria* it is analogous to a randomized head tax.

Let us now consider an example to understand the specific formula for computing the property tax. I will consider as an example a property located in the neighborhood of Dateo in Milan. This property has 7 *vani* and is of category A/3 and class 3. Given these coordinates we can infer that the *tariffa d'estimo* is of 116.2 €/vanno. I will consider the municipal tax rate set by the administration of Milan in 2007 which is of 0.0047. Thus the tax due for the year 2007 of the example property is:

$$116.2\text{€/vanno} * 160 * 1.05 * 0.0047 * 7 \text{ vani} = 643.26\text{€}$$

Even though the tax was set close to the low boundary of the allowed tax by a municipal administration that was very close to Berlusconi and thus politically adverse to the property tax, it is a sizable amount. To give an idea of the size of the tax let us consider the yearly rent for this property if it was rented for the full year. The average rent per square meter for a property of average quality in the neighborhood of Dateo in 2007 was 11.75€. Considering that the property has approximately 100 square meters, the yearly rent was 14.100€. This translates to a 4.5% property tax for this specific assessment, which was particularly generous to the owner.

The framework of the Italian property tax provides a valuable spatial variation which I will exploit later on in the present study. At the same time, given that the *zona censuaria* in most cases is not orthogonal to the distance from the city centre and to local amenities, a further source of variation is needed. What will provide this are the series of reforms of the property taxation between the years 2008 and 2014 which affected the size of the tax base significantly.

The experience of the third Berlusconi government ended in 2006 following the natural course of the parliamentary calendar of the Italian Republic and two political poles emerged participating in the subsequent elections. Silvio Berlusconi led the centre-right, while Romano Prodi led the centre-left. During the 2006 elections Berlusconi publicly declared during a televised debate that, if elected, he would have abolished the property tax on the main residences.<sup>25</sup> While the centre-right coalition lost the 2006 elections, the following centre-left government led by Prodi lasted less than two years and the country went back to elections in 2008. The result was a large majority for the

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<sup>25</sup>In Italian *prime case*

centre-right coalition and the birth of the fourth Berlusconi government. In line with the previous promises the new government abolished the property tax on the main residences.

Later, during the crisis of the early 2010's the tax was rebranded as the Imposta Municipale Unica (IMU) and reintroduced on the main residences during the passage between the fourth Berlusconi government and the technocratic Monti government. Lastly the tax was abolished again on the main residences by the coalition government of Letta in 2014. As I will argue later these institutional changes will provide a new source of variation for this study. For completeness I will report that in 2020 the second Conte government created a 'New IMU' which incorporated part of other local taxes, in particular the one named TASI, which shifted an additional fiscal burden from the renters to the landlords. Table 19 summarizes the institutional changes of the tax.

| Year | Event                                                                |
|------|----------------------------------------------------------------------|
| 1992 | ISI/ICI is introduced.                                               |
| 2006 | Berlusconi campaign promises.                                        |
| 2008 | ICI abolished on the main residences.                                |
| 2011 | ICI rebranded as IMU and applied again on the main residences.       |
| 2014 | IMU abolished on the main residences.                                |
| 2020 | New IMU introduced, further shift of the fiscal burden on landlords. |

Table 19: Italian property tax timetable.

### 3.4 Data

In order to estimate the effect of the Italian property tax on residential properties and its vertical equity, two datasets are required. On the one hand it is necessary to collect the information to construct the assessed values of the properties, while, on the other hand, the actual market price are needed. I will first describe the former and then the latter source.

As described in the previous section, in order to compute the assessed value of a property I need the category, the *tariffe d'estimo* and the location of a property. With these it is possible to compute the estimated price per *vano* and thus the tax owed to the state. The tables with the *tariffe d'estimo*

are publicly available on the site of the *Gazzetta Ufficiale*, the official Italian legislative journal. I collect for each *Zona Censuaria* the median class for a residential property of class A/3 (demotic residential properties). I also check that the ratio between the *tariffe d'estimo* for properties of class A/2 (residential properties) and A/3, and it is roughly constant, thus validating the choice for the incidence of taxation proxy.

Collecting the maps of the *zone censuarie* is a more complicated matter. At the moment information regarding which *zona censuaria* a property belongs to is registered in the legal document certifying ownership of a property at the Italian cadastre, but the overall maps which divide the specific municipal area in different *zona censuaria* are not easily accessible. In order to collect these I have created a list of the 82 provincial (NUTS 3) capitals which have more than one *zona censuaria* and I have contacted directly the local offices of the cadastre. A subset of these have answered with different sources which then I map directly or through the cadastral parcels maps on QGIS. The current study works with the regional (NUTS 2) capitals which have answered me. Table 20 provides a summary of the cities of which I currently have a digitalised map of the different *zone censuarie*. The current set of cities provides both spatial variation across the country and variation in size.

| City       | Current Population | Area                     | N. ZC |
|------------|--------------------|--------------------------|-------|
| Rome       | 2'758'243          | 1'287.36 km <sup>2</sup> | 7     |
| Milan      | 1'370'948          | 181.67 km <sup>2</sup>   | 3     |
| Torino     | 845'007            | 130.01 km <sup>2</sup>   | 4     |
| Palermo    | 628'317            | 160.59 km <sup>2</sup>   | 5     |
| Bologna    | 392'671            | 140.86 km <sup>2</sup>   | 2     |
| Firenze    | 367'015            | 102.32 km <sup>2</sup>   | 3     |
| Perugia    | 163'557            | 449.51 km <sup>2</sup>   | 2     |
| Campobasso | 47'334             | 56.11 km <sup>2</sup>    | 3     |
| Aosta      | 33'186             | 21.39 km <sup>2</sup>    | 3     |

Table 20: Mapped cities.

Regarding the market price of housing I rely on the Osservatorio del Mercato Immobiliare (OMI), a centre study of the Agenzia delle Entrate, the Italian tax authority which oversees the cadastre. The think tank follows the movements of the Italian real estate market through the actual deeds.<sup>26</sup> They divide the whole country in several homogeneous socio-economic areas and then they provide a range of possible values per square meters both for renting and buying for different types of real estate (i.e. residential buildings, offices, industrial buildings, etc.) and different levels of quality (low, normal, and high).<sup>27</sup> The different areas, which I will refer to as OMI areas, are further categorized with respect to their relative position in the local jurisdiction. In particular five areas are defined: B, C, D, E, and R, where B indicates central areas, C semi-central ones, D peripheral, E suburban, and R extra-urban. Data is available between the second semester of 2002 and the second semester of 2021. It is important to stress that prices for residential properties are partially reported since second semester of 2003 and fully since the first semester of 2004. Lastly, it is important to stress that the OMI revises the OMI areas approximately every 10 years. The only revision up to now has happened in 2014, which has updated the different areas, but it is not possible to easily connect an area post update to the one pre update.

Summarizing, if I refer to the Roman C40 area, set in 2021, I refer to the area that covers roughly the Rione Prati in Rome, which is categorized as semi-central. Unless specified I will always restrict my analysis to civilian residences. Table 21 summarizes the dataset.

|             | Number of OMI areas | Min per city | Max per city | Average per city |
|-------------|---------------------|--------------|--------------|------------------|
| Pre-update  | 10'158              | 273          | 5'091        | 1'128.7          |
| Post-update | 7'417               | 154          | 3'586        | 824.1            |

Table 21: Summary statistics of the number of OMI zones.

<sup>26</sup>Thus, post eventual negotiations.

<sup>27</sup>The OMI specifies that properties that are outliers in the range, due to extremely low quality maintenance or, in the other sense, high production value and market assessment, are excluded. Think of rundown buildings in the first case and projects designed by renowned architects in the peripheries in the other case.

### 3.5 Reduced Form Analysis

#### 3.5.1 Identification Strategy

The aim of the paper is, primarily, identify the effect of the Italian assessed value tax on the market price of residential properties. To do so I exploit two types of variation due to the Italian fiscal framework. From a temporal point of view the three reforms of the fourth Berlusconi, the Monti, and the Letta governments respectively, provide a national change in the incidence of the tax. Most residential properties in urban areas that were not in the renting market were now exempted from the tax. Concentrating simply on this type of variation, though, would leave us exposed to the same political problem as before: property taxes are endogenously set by politicians interested in re-election and the revenue of such tax is tied to local public good provision, which alone is an important determinant of house prices themselves. Providing spatial variation across municipalities would not alleviate the problem as the local administrations are the collectors of the tax and the main providers of local public goods. In order to counter this issue I exploit the within city variation of the assessed value of a property due to the existence of different *Zone Censuarie* in large towns. Given that a city cannot differentiate the tax rate within its boundaries, only across category of properties, and it provides the same public goods across its jurisdiction, the main variation, once we control for the specific OMI area, is the estimation of the property by the state and thus the incidence of the property tax. This identification strategy should alleviate the endogeneity issue that arises when measuring tax capitalization.

The main regression will thus be as following

$$\text{Price}_{t,o,l,q} = \alpha + \mathbb{1}(\text{Tax on main residences}) * \beta_o * \text{Tariffa d'Estimo}_{o,l} + \gamma_o + \gamma_t + \gamma_{c,t} + \gamma_q. \quad (33)$$

The indicator function is equal to 1 when the tax applies on the main residences, between 2003 and 2008 included and between 2012 and 2014 included. With subscript t I indicate time, measured in semesters, while subscript o indexes OMI areas, subscript l whether I refer to the upper or lower bound of the square meter price for a specific OMI area and a specific semester, subscript c indicates a municipality, and, lastly, subscript q indicates, where available, the quality of a property. Thus, I will measure the effect of higher value estimations of a property, and thus higher taxes, on its price. I include fixed effects for the following elements:

- **OMI areas:** a fixed effect which should capture local amenities and the distance from the

central business district. As OMI areas are computed to be socio-economically homogeneous, they should also capture, at least partially, the income sorting of individuals within a city.

- **Semester:** A time fixed effect.
- **City-semester:** A fixed effect capturing local municipal trends. Variations in the local tax rate and in the provision of local public goods will be captured by this set of dummy variables. Providing the control for smaller geographical areas would have been unfeasible as the number of dummy variables would have greatly risen. I regard the city-semester specification an acceptable, albeit not perfect, level in order to capture the effects of interest.
- **Quality:** When data is available I can control for the quality of the property. Quality captures maintenance levels and the quality of the internal finishes. For commercial properties such as shops, it measures also the quality of the position of the property itself.

The identification described by [33](#) should allow me to avoid the strategic tax rate choice of municipalities before the implementation of the Berlusconi reform. Given the concentric nature of the *zone censuarie*, the identification strategy would suffer from different within city property price trends. If central location, which have higher assessed values than peripheral ones. I provide additional specification in the robustness checks section to account for this potential threat.

In order to further capture the trends in prices across time, I then further enhance the estimation by allowing the effect of the property assessment on prices to vary across time. Thus, the second model to be estimated is

$$\text{Price}_{t,o,l,q} = \alpha + \sum_{t=1}^T \mathbb{I}(\text{Tax on main residences}) * \beta_{t,o} * \text{Tariffa d'Estimo}_{o,l} + \gamma_o + \gamma_t + \gamma_{c,t} + \gamma_q. \quad (34)$$

Given that municipalities could adjust their tax rate autonomously and strategically before the implementation of the reform, I do not claim a parallel trends assumption as in a standard DiD identification strategy. For instance, the municipality of Milan already lowered the tax rate as the mayor was a close political ally of Berlusconi and intended to showcase the flagship Berlusconi policy before the national election. In this sense, there is a possibility that local administrations front loaded an expected national policy in order to reap possible political benefits in advance.

When referring to office prices and rents I will use the same specifications. Unless specified the dependent variable will always indicate per square prices unless specified otherwise.

### 3.5.2 Main Results

First I will report the results for the regression over all nine cities with respect to equation [33](#). Standard errors are clustered at the OMI area level. In table [22](#) I display the main results of the base regressions. Column (1) indicates the regression for the lower bound of the residential per square meter prices, while column (2) reports the same results for the higher bound.

| Prices                  | (1)       | (2)       |
|-------------------------|-----------|-----------|
| <i>Tariffa d'estimo</i> | -1.043*** | -1.405*** |
|                         | (0.250)   | (0.270)   |
| N                       | 22542     | 22542     |
| R <sup>2</sup>          | 0.975     | 0.968     |
| Bound                   | Lower     | Upper     |

Table 22: Table of Results: National.

First of all it can be pointed out that the tax is, indeed, capitalized in the residential properties. Given that the proxy of the *tariffa d'estimo* cannot be tied one to one to the actual tax paid by the property owners, an additional euro in the *tariffe d'estimo* does not translate into an additional euro owed to the local governments, but it depends on the specific property and the tax rate of the local jurisdiction. Having specified this, we can still observe that a higher *tariffa d'estimo* does translate in higher taxes, thus the regression results still let us observe the direction of the effect of the property tax on prices and the magnitude of the effect keeping the assessment of a property constant.

While we cannot reject the hypothesis that the two coefficients are the same, the results are consistent with the Hamilton theoretical findings that argue that, with a property tax in a mixed community, higher priced properties are traded with a discount, as they overpay in taxes for the public good as long as the number of *vani* is constant. It is also possible that the regression is capturing differences in sizes for properties at different points in the distribution of prices. In particular, if the properties are traded with a premium based on size where larger properties are traded at a higher per square meter price, then the regression might be capturing the fact that the

properties closer to higher bound of the distribution of sizes tend to be larger and, thus, pay more taxes. What I would be capturing is the effect of a larger reduction in taxes rather than a different impact of the same tax on unobservables. Even though I cannot rule out this hypothesis, I can at least argue that given that the Italian fiscal framework takes into account the room count of a property (and not even all of the rooms) rather than the size. Thus there is scope for some variation in size with no change in the property tax levied on a property.

To further test the mechanism we can report the same result for a set of subsamples of the dataset. In particular, I will run the same regression as specified in equation 33 for the four largest cities of the nine included in the dataset: Rome, Milan, Turin, and Palermo. These are four of the five largest Italian town and geographically dispersed around the country. The results are summarized in tables 23 and 24.

| Prices                  | (1)       | (2)       | (3)       | (4)       |
|-------------------------|-----------|-----------|-----------|-----------|
| <i>Tariffa d'estimo</i> | -1.461*** | -2.876*** | -1.168*** | -1.010*** |
|                         | (0.174)   | (0.251)   | (0.230)   | (0.358)   |
| N                       | 8677      | 8677      | 4690      | 4690      |
| R <sup>2</sup>          | 0.980     | 0.977     | 0.969     | 0.958     |
| Quality FE              | No        | No        | Yes       | Yes       |
| City                    | Rome      | Rome      | Milan     | Milan     |
| Bound                   | Lower     | Upper     | Lower     | Upper     |

Table 23: Table of Results: Rome and Milan.

| Prices                  | (1)     | (2)     | (3)       | (4)       |
|-------------------------|---------|---------|-----------|-----------|
| <i>Tariffa d'estimo</i> | -0.318  | -1.180* | -2.130*** | -3.381*** |
|                         | (0.426) | (0.636) | (0.471)   | (0.607)   |
| N                       | 2056    | 2056    | 1823      | 1823      |
| R <sup>2</sup>          | 0.920   | 0.915   | 0.965     | 0.968     |
| Quality FE              | Yes     | Yes     | No        | No        |
| City                    | Turin   | Turin   | Palermo   | Palermo   |
| Bound                   | Lower   | Upper   | Lower     | Upper     |

Table 24: Table of Results: Turin and Palermo.

Columns (1) and (2) of table 23 refer, respectively, to the lower bound and the higher bound of Roman residential properties prices. Analogously, columns (3) and (4) of the same table refer to Milanese prices. Columns (1) and (2) of table 24 refer to Turinese prices, and (3) and (4) of the same table to Palermitan prices. Given the reduces sample of observation, the noise inevitably increases and the results are less precise. For this reason I am not clustering the standard errors. In any case the general picture is consistent with the national results. For Rome, Turin and Palermo we observe the same pattern as at the national level, where the capitalization of the property tax at the higher bound is higher than the lower one. This is particularly true for Rome where we have a higher number of observations and we can safely exclude the null hypothesis that the two values are the same. The picture is slightly different for Milan, where the capitalization is higher at the lower bound of the distribution, but only slightly and with large confidence interval. As such I don't regard it as a strong evidence against the other results.

I can now turn to the policy impact analysis as specified in equation 34. As before I report first the national analysis in figures 9 and 10.

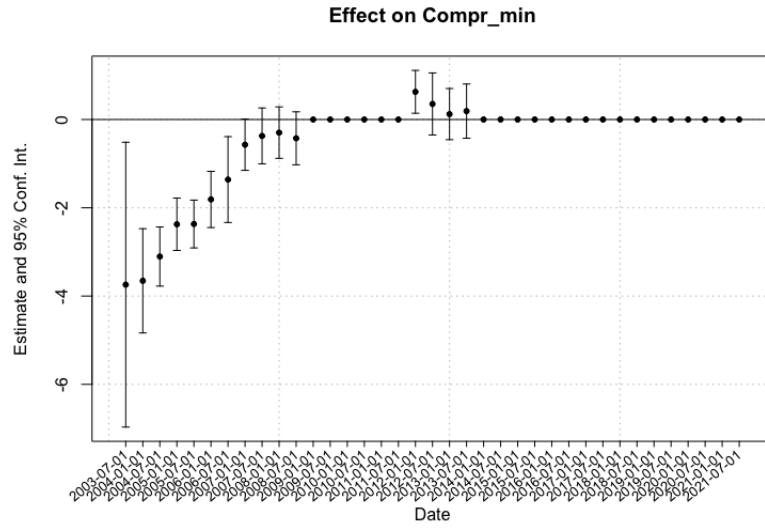


Figure 9: Policy impact on the lower bound at the national level

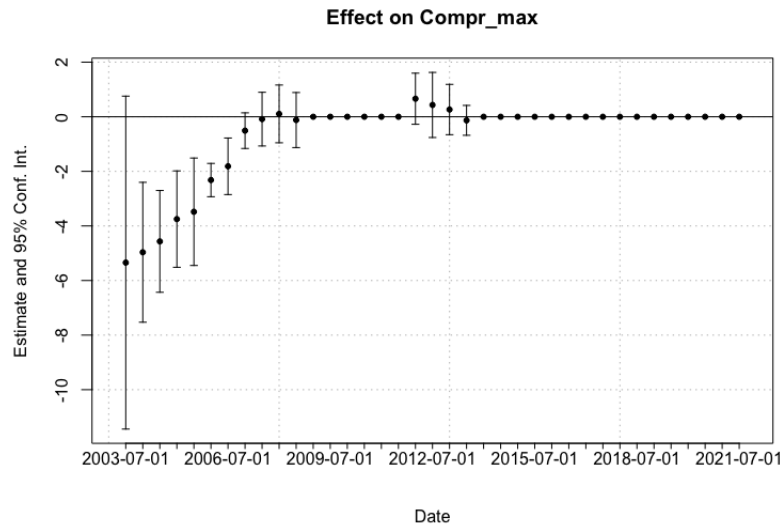


Figure 10: Policy impact on the upper bound at the national level

As in the previous analysis, it is possible to observe that before the first policy intervention (the one set by the fourth Berlusconi government in 2008) residential property prices capitalized the property tax. Additionally, the upper bound of property prices faces a larger reduction than the

lower one at every period. We can further dive in the trend of property prices. First, the effect of the property tax is present in the period 2003-2008, while it is less clear in the period 2012-2014. It is possible that the political and economic turbulence of the early 2010s led to a lower capitalization of the tax. Let us then focus of the 2003-2008 period. There seems to be an upward trend in the residential property prices tied to the assessment of the property, and thus on the tax. In particular, in the two years before there seems to be no effect on the residential property prices of the property tax. As described in section III, the increase in prices between the first semester of 2006 and that of 2007 aligns with the public Berlusconi announcement that the centre-right coalition would adopt the abolition of the property tax on the main residences as their flagship policy. Given that the second Prodi government, in charge between the second half of 2006 until the beginning of 2008, was particularly precarious, it seems reasonable that homebuyers and homesellers started to price in the reduction in taxes starting from 2006 and expecting a centre-right government in the following years.<sup>[28]</sup> It is possible that the absence of capitalization in the period between 2012 and 2014 was also due to the public considering the tax as temporary.<sup>[29]</sup> Lastly, the high confidence interval for the year 2003 is due to the low amount of observations regarding civilian properties for that year.

If we delve in the same analysis for the four main cities considered in the sample we observe a similar pattern.<sup>[30]</sup> In all cities we observe an upward trend in the period 2003-2008, with a specific increase around the period 2006-2007. Excluding Milan, where the pattern is mixed, the effect of the property tax is higher on the upper bound of prices than on the lower one. Lastly, an interesting trend that is particularly clear in the cases of Turin and Palermo, in the 2012-2014 period there seems to be a down-ward trend of prices which supports the hypothesis that the tax took time to be capitalized, possibly due to the correctly perceived temporary political equilibrium in favour of the tax.<sup>[31]</sup>

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<sup>28</sup>The second Prodi government was a precarious government composed by seven parties large enough to form a group in the Senate and several others that did not reach that threshold, plus the support of other nine parties as external supporters. Given that the government had a majority of 10 senators at the beginning of the legislature, it is clear why the government lasted less than two years, including the care-taking period in 2008.

<sup>29</sup>Berlusconi did campaign against the reintroduction of the property tax, even though his party supported the Monti government.

<sup>30</sup>The figures are in the appendix.

<sup>31</sup>The specific results are reported in the appendix in figures from <sup>[25]</sup> to <sup>[28]</sup>

### 3.5.3 Robustness Checks

As described before in the data section, the OMI areas are updated every 10 years. This has happened once, in 2014, and thus the location fixed effects in the main analysis also capture some time trend. Given that the change happened concurrently to one of the policy changes of interest, I try the same analysis as before but I restrict the time frame to the 2003-2014 period. The results are shown in table 25.

| Prices                  | (1)       | (2)       |
|-------------------------|-----------|-----------|
| <i>Tariffa d'estimo</i> | -1.042*** | -1.406*** |
|                         | (0.117)   | (0.179)   |
| N                       | 13437     | 13437     |
| R <sup>2</sup>          | 0.974     | 0.968     |
| Bound                   | Lower     | Upper     |

Table 25: Table of Results: National (2003-2013).

As before column (1) reports the coefficient for the lower bound of residential property prices, while column (2) reports the same result for the upper bound. The coefficients are similar to the one obtained in the previous subsection. In tables 31 and 32, reported in the appendix, I replicate the analysis of the four main cities with the reduced sample. Again, I obtain the same results.

A possible alternative explanation for the results is that what we are capturing is not the effect of the policy intervention regarding the property tax, but the different trends in property prices within the Italian cities. Let us suppose that in the period between 2003 and 2021, properties at the center of the respective cities were traded at increasingly higher prices relative to the other ones. Given that properties have higher *tariffe d'estimo* when they are closer to the respective city centre, the two factors are not orthogonal to each other. As a first test I run the same regression as in equation 33 considering only the first two *zone censuarie*, the central ones, for the city of Rome. The selection of Rome, which has several *zone censuarie* and a large number of OMI areas, enables me to focus on differences on taxation within the city centre. While the first *zona censuaria* of Rome covers the city centre, the second one still covers wealthy areas with high property prices such as Trastevere,

Rione Prati and the area surrounding La Sapienza university. The results are reported in table [26](#).

| Prices                  | (1)       | (2)        |
|-------------------------|-----------|------------|
| <i>Tariffa d'estimo</i> | -5.391*** | -11.631*** |
|                         | (0.412)   | (0.549)    |
| N                       | 953       | 953        |
| R <sup>2</sup>          | 0.977     | 0.978      |
| Bound                   | Lower     | Upper      |

Table 26: Table of Results: Excluding the peripheries (Rome).

As usual column (1) refers to the results regarding the lower bound, while column (2) refers to the one regarding the upper bound. The results are consistent with the previous results but the higher values for the coefficient, with respect to the previous ones, seem to point out that the effect of the tax is larger at the centre of Rome.

To further control for these trends I run the following specification

$$\text{Price}_{t,o,l,q,r} = \alpha + \mathbb{1}(\text{Tax on main residences}) * \beta_o * \text{Tariffa d'Estimo}_{o,l} + \gamma_o + \gamma_t + \gamma_{c,t} + \gamma_{r,t} + \gamma_q. \quad (35)$$

Where the additional term  $\gamma_{r,t}$  indicates a time-relative location within a city set of fixed effects. As reported in the data section, the OMI analysis associates to each of the OMI areas a letter indicating the relative position of the area within a city.<sup>32</sup> The results of the new specification are reported in table [27](#).

<sup>32</sup>Central, semi-central, peripheral, sub-urban, and extra-urban.

| Prices                  | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| <i>Tariffa d'estimo</i> | -0.665*** | -0.701*** | -1.283*** | -2.361*** | -0.585*** | -1.408*** |
|                         | (0.151)   | (0.225)   | (0.272)   | (0.379)   | (0.181)   | (0.229)   |
| N                       | 22542     | 22542     | 8677      | 8677      | 18107     | 18107     |
| R <sup>2</sup>          | 0.976     | 0.969     | 0.982     | 0.981     | 0.979     | 0.981     |
| City                    | National  | National  | Rome      | Rome      | No Milan  | No Milan  |
| Bound                   | Lower     | Upper     | Lower     | Upper     | Lower     | Upper     |

Table 27: Table of Results: Including within cities time trends.

In columns (1) and (2) I report the results, respectively for the lower and upper bounds, for the regression [35](#). With these specifications we still observe the effect of the capitalization, but the difference between the coefficients relative to the lower and upper bounds disappears. To check for the robustness of this last result, I restrict the analysis in columns (3) and (4) to the city of Rome. Here the difference reappears but the magnitude is lower than the results reported in tables [23](#) and [24](#), suggesting that the previous equations were not distinguishing between within city time trends and the policy impact. Lastly, given the results of tables [23](#) and [24](#) where the city of Milan was the only one that did not display a sizable difference between the lower and upper bounds point estimate, I try running the same regression as before, excluding Milan. The results are reported in columns (5) and (6) where the results are consistent with the previous results.<sup>[33](#)</sup>

### 3.5.4 Additional Results

The capital-tax view relies on the second order effect of a property tax on capital allocation decisions. The argument rests on a inter-jurisdictional approach, where capital is allocated to different jurisdictions based on the deviation from the average tax rate. Given that the current reduced form study focuses on within city price effects, we cannot test the assumption directly. On the other hand, the policy changes for the Italian property tax applies only on main residences, thus we can still test for second order effects on the Italian property market. In particular, the OMI dataset

<sup>33</sup>It is not clear, at the moment, why Milan would display different results other than chance.

reports prices for several type of properties, such as offices, warehouses, and garages. If the property tax influences capital allocation across jurisdiction it must do so as well across different types of property, and such effect should be captured in the different prices.

There might be two possible mechanisms for this to happen. The first one is through land prices and conversion costs. Absence of a tax leads to an increase in construction for residential properties, thus increasing the demand for land and its prices. Higher input costs then get, at least partially, passed through all types of property. By this mechanism alone, the supply of other properties in absolute terms is not affected. It is clear that this channel would not be active in a highly urbanized environment, where brand new constructions are rare given the scarcity of free land. The second channel is category conversion. If the policy impact of the removal of the property tax leads higher prices for residential properties, then, at the margin, will be convenient for the owners of non residential properties to convert them to residential ones. The reduced supply of non residential properties, then, drive up their prices even though they are not affected directly by the new policy.

With the current data it is not possible to distinguish between the two channels, but it is possible to use the same econometric specification of equation 35 to test whether these second order effects are present. In tables 28 and 29 I report the results for the following categories: offices, warehouses, shops, garages, laboratories, and industrial sheds.

| Prices                  | (1)       | (2)       | (3)        | (4)        | (5)     | (6)       |
|-------------------------|-----------|-----------|------------|------------|---------|-----------|
| <i>Tariffa d'estimo</i> | -0.724*** | -1.636*** | -0.106     | -0.493***  | -0.247* | -0.676*** |
|                         | (0.152)   | (0.188)   | (0.071)    | (0.103)    | (0.128) | (0.156)   |
| N                       | 17666     | 17666     | 6373       | 6373       | 17875   | 17875     |
| R <sup>2</sup>          | 0.983     | 0.985     | 0.981      | 0.984      | 0.983   | 0.986     |
| Category                | Offices   | Offices   | Warehouses | Warehouses | Garages | Garages   |
| Bound                   | Lower     | Upper     | Lower      | Upper      | Lower   | Upper     |

Table 28: Table of Results: National for offices, warehouses, and garages

| Prices                  | (1)       | (2)       | (3)          | (4)          | (5)     | (6)     |
|-------------------------|-----------|-----------|--------------|--------------|---------|---------|
| <i>Tariffa d'estimo</i> | −2.012*** | −2.630*** | −0.356***    | −0.528***    | 0.057   | 0.069   |
|                         | (0.479)   | (0.718)   | (0.097)      | (0.126)      | (0.071) | (0.080) |
| N                       | 17226     | 17226     | 6610         | 6610         | 3987    | 3987    |
| R <sup>2</sup>          | 0.921     | 0.908     | 0.977        | 0.978        | 0.984   | 0.986   |
| Category                | Shops     | Shops     | Laboratories | Laboratories | Sheds   | Sheds   |
| Bound                   | Lower     | Upper     | Lower        | Upper        | Lower   | Upper   |

Table 29: Table of Results: National for shops, laboratories, and industrial sheds

The results reported in the two tables are consistent with the within city capital-tax view, and in particular, with the conversion channel. Properties that were not directly affected by the fiscal policy changes between 2008 and 2014, display a drop in prices that cannot be explained by local trends. Additionally, the effect seems larger for shops and offices, while the null hypothesis cannot be rejected for the lower bound of warehouses and for industrial sheds in general. The coefficients are, then, consistent with the idea that the increase in prices due to the removal of the Italian property tax led to the conversion of non-residential properties to residential ones. The following fall in supply increased their prices as well. Additionally, the magnitude of the coefficient is smaller for those types of properties that are more difficult to convert to residential properties. As suggested by the capital-tax view when applied to a within city analysis, the Italian property tax distorts the supply of properties along different categories.

Another possible channel for distortion, that is consistent with the capital-tax view, is a shift in the supply of rented residential properties, relative to the ones that are sold. Again, an increase in residential property prices due to an increase in demand, will affect the decision of property-owners on whether to rent or sell their properties. The change in supply should affect their prices. I run the same regression as specified in equation [35](#) and I report the results in table [30](#).

| Rents                   | (1)      | (2)      | (3)     | (4)     |
|-------------------------|----------|----------|---------|---------|
| <i>Tariffa d'estimo</i> | -0.024   | 0.025    | -0.007  | -0.055  |
|                         | (0.017)  | (0.019)  | (0.052) | (0.064) |
| N                       | 22542    | 22542    | 8677    | 8677    |
| R <sup>2</sup>          | 0.603    | 0.493    | 0.6     | 0.419   |
| City                    | National | National | Rome    | Rome    |
| Bound                   | Lower    | Upper    | Lower   | Upper   |

Table 30: Table of Results: Rents.

In column (1) and (2) I report the result for the regressions at the national level, column (3) and (4) restrict the sample to the city of Rome. As usual odd columns report the results for the lower bound, while even ones report the results for the upper bound. In none of the four regressions we can reject the null hypothesis, even in Rome where the effect of the fiscal policy change was more stressed.

### 3.6 Model

The previous literature on tax capitalization has mostly failed to incorporate any debate regarding the theoretical innovations of the economic geography literature. To start bridging the two literature I embed a fiscal element, based on a property taxation framework similar to the Italian one, into a monocentric city model.

Let me first define a baseline model with two types of housing, one with better unobservable than the other in order to capture what Hamilton referred to as mixed communities.

#### 3.6.1 Baseline Model

The model is composed by three types of agents arranged on a line representing the distance from the central business district of an urban agglomeration. Households decide where to reside in and commute to the central business district supplying their unit labor inelastically. Additionally they decide which type of housing to reside in and how much of a consumption good to consume. Pro-

ducers decide how much labor and capital to use in order to produce the consumption good. Lastly, the capital owners supply their capital either to the production of the two types of housing or to the producers. As usual the equilibrium conditions close the model.

Let us first define the producer problem. Producers act in an environment of perfect competition by optimizing their mix of labor and capital input in order to serve the urban environment. In order to simplify the problem, and given that the producers are equal, I consider the problem in the aggregate. Mathematically

$$\begin{aligned} \text{Min}_{L, Q^d} \quad & wL + rQ^d. \\ \text{S.t.} \quad & x^s = P(L, Q^d). \end{aligned} \tag{36}$$

Where  $w$  is the wage,  $L$  the demand of labor,  $Q^d$  is the demand of capital, and  $r$  the price of capital. Lastly  $P(\cdot)$  is the production function of the firm and  $x$  the amount of consumption good produced and is taken as given. Given that producers are in perfect competition the solution of this problem is given by the two following conditions

$$P_L(L, Q^d) = w. \tag{37}$$

$$P_Q(L, Q^d) = r. \tag{38}$$

The city is composed by  $N$  Households, which have several choices to make. First, they have to choose whether to consume housing with more or less unobservables. Where houses with more unobservables provide higher utility, everything else constant. We can think of houses with higher unobservables as housing units with better characteristics, such as better location with respect to light, external sound, in addition to floor level, quality of insulation and materials used. Second, they need to choose where to locate themselves within the city, and thus the cost of commuting. Lastly, they have to decide their consumption bundle, between the consumption good and housing. All agents have the same utility function  $U(H_h^d(t), H_l^d(t), x^d(t)) \geq 0$  which has the following specification

$$\begin{aligned} U(H_h^d(t), H_l^d(t), x^d(t)) = & \mathbb{1}(H_h^d(t) > 0)(1 - \mathbb{1}(H_l^d(t) > 0)) u^h(H_h^d(t), x^d(t)) \\ & + \mathbb{1}(H_l^d(t) > 0)(1 - \mathbb{1}(H_h^d(t) > 0)) u^h(H_l^d(t), x^d(t)) \end{aligned} \tag{39}$$

Where  $x^d(t)$  indicates the amount of consumption good picked by the agent.  $H_q^d$  is the demand for housing, where  $q \in \{h, l\}$  indicates the amount of unobservables, high ( $h$ ) or low ( $l$ ). The utility is such that

$$U(0, H_l^d(t), x^d(t)) = U(H_h^d(t), 0, x^d(t)) = U(H_h^d(t), H_l^d(t), 0) = 0 \quad (40)$$

Given the generality of the production function for housing in equation (54),  $H_q^d$  can indicate both the size of the house and the observable quality. The difference between observable and unobservable features will be important once we set up the fiscal framework in the following subsection. The two functions defined as  $u_q^d(H_q^d(t), x^d(t))$  are both monotone increasing functions in both terms, with monotone decreasing first derivatives in both inputs. The function is defined such that housing and consumption are both normal goods. Furthermore the second derivatives are set as follows

$$\frac{\partial^2 u^q(H, x)}{\partial H^2} \leq 0 \quad (41)$$

$$\frac{\partial^2 u^q(H, x)}{\partial x^2} \leq 0 \quad (42)$$

$$\frac{\partial^2 u^q(H, x)}{\partial H \partial x} \geq 0 \quad (43)$$

Where the three conditions indicate a decreasing utility gains as the consumption of a good increases and some complementarity between the two. Residential properties with higher unobservables provide higher utility holding everything equal such that

$$u^h(H, x) \geq u^l(H, x) \quad (44)$$

And

$$\frac{\partial u^h(H, x)}{\partial H} > \frac{\partial u^l(H, x)}{\partial H} \quad (45)$$

Additionally, I impose some relative conditions on the ratio of the derivatives

$$\frac{\partial u^h(H, x)}{\partial H} \frac{\partial u^l(H, x)}{\partial x} > \frac{\partial u^l(H, x)}{\partial H} \frac{\partial u^h(H, x)}{\partial x} \quad (46)$$

This condition specifies that, holding consumption equal, the agent consuming housing with a high level of unobservables has a relative preference for consuming housing with respect to other goods higher than the household consuming housing with a low level of unobservables.

The utility function captures the fact that an household only buys a single property of a specific level of unobservables  $q$ . Given that it is always preferable for an household to buy a single type of property it is possible to define two different problems: one for the households that acquire properties of  $q = l$  and one for those who buy properties with  $q = h$ . An indifference condition, defined later in this section with equation (60), guarantees the equilibrium among the agents. Additionally, given that the two types of agents might pick different amount of consumption goods at the same location I define the following decomposition.

$$x^d(t) = x_h^d(t) + x_l^d(t) \quad (47)$$

As such the problem, given the amount of unobservables  $q$ , is

$$\begin{aligned} \text{Max}_{x_q^d(t), H_q^d(t), t} \quad & u^q(x_q^d(t), H_q^d(t)). \\ \text{S.t.} \quad & w - k(t) = px_q^d(t) + p^q(t)H_q^d(t). \end{aligned} \quad (48)$$

Where  $p$  is the price of the consumption good.  $k(t)$  is a function defining the commuting cost, increasing in  $t$  which defines the distance from the central business district. Lastly,  $p^q$  indicates the price of a unit of housing.

Solving the problem we obtain the two following conditions

$$\frac{p^q(t)}{p} = \frac{u_{H_q^d(t)}^q(x_q^d(t), H_q^d(t))}{u_{x_q^d}^q(x_q^d(t), H_q^d(t))} \quad \forall q \in \{h, l\} \wedge \forall t. \quad (49)$$

$$w - k(t) = px_q^d(t) + p^q(t)H_q^d(t) \quad \forall q \in \{h, l\}. \quad (50)$$

Where, for tractability, I indicate with  $u_{H_q^d(t)}^q(x_q^d(t), H_q^d(t))$  the derivative of the utility function  $u^q(x_q^d(t), H_q^d(t))$  with respect to  $H_q^d(t)$ .

Lastly it is possible to define the problem of the capital owners. I assume that capital is provided competitively. Again, given that they are equal and are price takers, I can consider a single representative capital owner. The capital owner supplies capital without frictions to the producers or to the households as housing by converting land. The owner maximises the following function

$$\begin{aligned} \text{Max}_{H_h^s(t), H_l^s(t), Q^s} \quad & \int_0^T [(p^h(t)H_h^s(t) - C_h(H_h^s(t), r_l(t)) + (p^l(t)H_l^s(t) - C_l(H_l^s(t), r_l(t)))]dt + \\ & Q^s r - C(Q^s). \end{aligned} \quad (51)$$

Where  $r_l(t)$  indicates the land rents and  $T$  the endogenously determined border of the city. Land is provided monopolistically by absent landowners. When supplying housing, capital owners convert land to housing at cost  $C_h(H_h(t), r_l(t))$  and  $C_l(H_l(t), r_l(t))$ , where both functions are increasing in both arguments and the second derivative in the amount of housing provided is always non-negative. Furthermore providing properties with a high level of unobservables is at least more costly than doing so for properties with low levels of unobservables, such that  $C_h(H, r_l(t)) \geq C_l(H, r_l(t))$  and  $\partial C_h(H, r_l(t))/\partial H \geq \partial C_l(H, r_l(t))/\partial H$  for all  $H$ , where the inequalities are strict as soon as  $H > 0$  and the cost of producing  $H = 0$  is equal to 0 for both production functions. At the same time capital owners provide capital to producers at cost  $C(Q^s)$  which is an increasing and convex function. Given that capital is allocated competitively we have that

$$p^h(t) = \frac{\partial C_h(H_h^s(t), r_l(t))}{\partial H_h^s(t)} \quad \forall t. \quad (52)$$

$$p^l(t) = \frac{\partial C_l(H_l^s(t), r_l(t))}{\partial H_l^s(t)} \quad \forall t. \quad (53)$$

$$r = \frac{\partial C(Q^s)}{\partial Q^s}. \quad (54)$$

We can now close the model by setting the equilibrium conditions. At equilibrium we have  $\{L, Q^d, Q^s, x^d(t), x^s(t), H_l^s(t), H_h^s(t), H_l^d(t), H_h^d(t)\}$  such that equations (37) - (38) - (49) - (50) - (52) - (53) - (54) all hold for all locations  $t$ . Additionally  $\{w, r, r_l(t), p^l(t), p^h(t), p\}$  such that all consumption goods are consumed in the city

$$\int_0^T x^d(t) dt = x^s = P(L, Q^d). \quad (55)$$

All citizens are hired

$$N = L. \quad (56)$$

The production capital market clears

$$Q^d = Q^s. \quad (57)$$

Both housing markets clear

$$H_h^s(t) = H_h^d(t) \quad \forall t. \quad (58)$$

$$H_l^s(t) = H_l^d(t) \quad \forall t. \quad (59)$$

To maintain the equilibrium we need that households are indifferent between locations such that

$$u^q(H_q^d(t), x^d(t)) = \bar{u} \quad \forall t. \quad (60)$$

From this condition we can observe that house prices, and thus land prices, must be declining as the distance from the central business district increases. To see so, let us suppose that the price are constant. But if the prices are constant, then residents closer to the central business district have higher budgets, due to the commuting costs, and thus higher utility. Given that the consumption good is freely traded within the city, higher house prices are needed to maintain the equilibrium.

Lastly we determine  $T$  by setting an exogenous agricultural land rent  $r_a$  such that at the border of the city we have that land owners are indifferent to whom they have to supply their land such that

$$r_l(T) = r_a. \quad (61)$$

I can state the formal definition of the equilibrium.

**Definition 1.** *I define the equilibrium as a set of variables  $\{L, Q^d, Q^s, H_l^s(t), H_l^d(t), H_h^d(t), H_l^s(t), H_h^s(t), x_l^d(t), x_h^d(t)\}$  such that the household problem [\[48\]](#), the producer problem [\[36\]](#), and the capital owner problem [\[51\]](#) are optimized at all locations, given the vector of prices, and the amount of consumption goods provided. The vector of prices, market goods supplied, utility level, and city size  $\{w, r, r_l(t), p^l(t), p^h(t), p, x^s(t), \bar{u}, T\}$  is set such that the markets for labor, capital, consumption goods, and housing all clear, as equations [\(56\)](#) - [\(55\)](#) - [\(57\)](#) - [\(59\)](#) - [\(58\)](#) hold at all locations, given the city size. Lastly, households are indifferent between locations, as equation [\(60\)](#) holds for all  $t \in [0, T]$  and the city boundary is defined by [\(61\)](#).*

We can now formally state Proposition [1](#) which states a sufficient condition for the existence of the equilibrium.

**Proposition 1.** *Consider the following conditions*

1. *The derivative of the utility function is continuous for all arguments.*

2. Considering the equilibrium conditions (49) - (50) - (52) - (53) - (61), the utility functions are either such that

$$\left. \frac{\partial u^h(H^h(T), x^h(T))}{\partial p} \right|_{p=0} > \left. \frac{\partial u^l(H^l(T), x^l(T))}{\partial p} \right|_{p=0}$$

and, for  $p \rightarrow \infty$

$$u^h(H^h(T), x^h(T)) = u^h(I(T)/p^h(T), 0) < u^l(H^l(T), x^l(T)) = u^l(I(T)/p^l(T), 0)$$

or if the inequality directions are inverted.

In case, instead, that

$$u^h(H^h(T), x^h(T)) = u^h(I(T)/p^h(T), 0) = u^l(H^l(T), x^l(T)) = u^l(I(T)/p^l(T), 0).$$

Then, the following inequality must hold with the opposite inequality sign than the first inequality of this condition

$$\frac{\partial u^h(H^h(T), x^h(T))}{\partial p} < \frac{\partial u^l(H^l(T), x^l(T))}{\partial p}.$$

3. Analogous to condition 2, but with a generic  $t$  and the derivatives with respect to  $r(t)$ .

These conditions are sufficient for the existence of the equilibrium of the baseline model described by definition 1.

Conditions 2 and 3 ensure that there exist a value  $p$  such that at  $t = T$  the system of equations described by (60) with unknown  $p$  and  $\bar{u}$  has a set of internal solutions. Analogously, conditions 4 and 5 guarantee the existence of  $r(t)$  for each  $t$ . For example it is the case of a Cobb-Douglas utility function with the same parameters, and as such there is either no solution to the system of equations that defines the equilibrium or there are infinite.

*Proof.* First we can simplify notation by noticing that the market clearing conditions (57) - (59) - (58) ensure that demand and supply match. As such we can write  $H_q^d(t) = H_q^s = H^q(t)$  and  $Q^s = Q^d = Q$ .

Now it is easy to determine the variables that solve the producer problem. Notice that  $L$  is pinned down by equation (56). Second, considering equations (54) and (38), we can determine  $Q$  and  $r$ . Lastly, through equation (37) we can determine  $w$ .

We can now turn to the remaining variables. First let us consider the case of  $t = T$ . Then equation (61) sets the land rent at the border. Then equations (49)-(50)-(52)-(53) will fix  $H^h(T)$ ,  $H^l(T)$ ,  $x^l(T)$ ,  $x^h(T)$ ,  $p^l(T)$ , and  $p^h(T)$  as functions of  $T$  and  $p$ . Then we can set  $p$  such that (60) holds for both levels of unobservables thanks to the intermediate value theorem. To see why, consider the cases under which  $p = 0$  or  $p \rightarrow \infty$ . Under both cases the utilities are both equal to 0. If either condition 2 holds, then according to the intermediate value theorem there must be at least an internal crossing between the two functions.

Having determined  $p$  and  $\bar{u}$ , we can now use equations (49)-(50)-(52)-(53)-(60) to fix  $H^h(t)$ ,  $H^l(t)$ ,  $x^l(t)$ ,  $x^h(t)$ ,  $p^l(t)$ ,  $p^h(t)$ , and  $r_l(t)$  for all locations. With a process analogous to the one above.

Lastly, the total size of the city is determined uniquely by equation (55) and by the intermediate value theorem.  $\square$

Now I will describe a simple but important result regarding the price of the two types of residential properties.

**Lemma 1.** *Given the equilibrium described by definition 1 and given any  $p, t, r_l(t)$ , it must be that  $p^h(t) > p^l(t)$ .*

*Proof.* I will consider the two cases  $p^h(t) < p^l(t)$  and  $p^h(t) = p^l(t)$ .

Let us first consider the latter. Given that the two types of household have the same budget constraint, it follows from equations (49) - (50) that  $H^h(t) > H^l(t)$ . To see why consider the following equations that holds at equilibrium due to  $p^h(t) = p^l(t)$

$$\frac{u_{H^h(t)}^h(x^h(t), H^h(t))}{u_{x^h(t)}^h(x^h(t), H^h(t))} = \frac{u_{H^l(t)}^l(x^l(t), H^l(t))}{u_{x^l(t)}^l(x^l(t), H^l(t))}$$

Consider a situation where both agents consume the same amount of housing and consumption goods. Then the household with  $q = h$  would prefer to increase its own consumption of housing as in equilibrium the condition above must hold. As such, it must be that  $H^h(t) > H^l(t)$ . Let us now consider the supply side and the properties of functions  $C^q(H^q(t), r_l(t))$ . If  $H^h(t) > H^l(t)$  it must follow that  $C_{H^h(t)}^h(H^h(t), r_l(t)) > C_{H^l(t)}^l(H^l(t), r_l(t))$ . But this last condition implies  $p^h(t) > p^l(t)$  and thus the initial condition does not hold.

Let us now consider the second scenario.  $p^l(t) > p^h(t)$  implies, through the supply side conditions, that  $H^l(t) > H^h(t)$ . On the demand side, the budget constraint implies  $x^h(t) > x^l(t)$  and it must be that

$$\frac{u_{H^h(t)}^h(x^h(t), H^h(t))}{u_{x^h(t)}^h(x^h(t), H^h(t))} < \frac{u_{H^l(t)}^l(x^l(t), H^l(t))}{u_{x^l(t)}^l(x^l(t), H^l(t))}$$

But given the condition imposed on the utility functions expressed by (46) and by (41) - (42) - (43), it must be that the inequality has the opposite sign. As such it is impossible that the demand side inequality holds and that  $p^l(t) > p^h(t)$ .  $\square$

Now I can provide an additional result regarding the consumption of housing and of the consumption good across the city.

**Lemma 2.** *Given the equilibrium described by definition 1, it must be that households consume less housing and more consumption good as they locate closer to the central business district.*

*Proof.* The first result to prove is that  $p^q(t)$  is a strictly decreasing function in  $t$ . For any set of parameters, the equilibrium implies that the income of the household  $w - k(t)$  is increasing in  $t$ . As such, if  $p^q(t)$  were constant, the utility of the household would be decreasing in the distance  $t$ . To guarantee the same level of utility across the city it must be that the prices of housing increase as the location is closer to the central business district to compensate for the increase in income. A decrease in distance  $t$  then implies directly a reduction in consumption of housing. The mediator for this process must be  $r_l(t)$  which must be a decreasing function in  $t$ .

Let us consider now the consumption of the consumption good  $x^q(t)$ . Let us assume that  $x^q(t)$  is increasing in  $t$ . If this were the case households closer to the central business district would consume less housing and, at most, the same amount of consumption good. Thus, given the properties of the utility function, it would imply a strictly lower utility level, and it would mean that an increasing function  $x^q(t)$  in  $t$  would not be compatible with the equilibrium described. Thus it must be that at equilibrium  $x^q(t)$  is a strictly decreasing function.  $\square$

Let us now further define the functional form of the utility function and the cost of providing the two housing goods. In particular I will define

$$u^h(t) = [(aH^h(t))^{\frac{\sigma-1}{\sigma}} + x^h(t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{1-\sigma}} \quad (62)$$

$$u^l(t) = [H^l(t)^{\frac{\sigma-1}{\sigma}} + x^l(t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{1-\sigma}} \quad (63)$$

Where  $a > 1$  and  $\sigma > 1$ . It is important to stress how the CES specification respects all the condition imposed in the generic model.

Regarding the cost of providing the housing good we have

$$C^h(H^h(t), r_l(t)) = H^h(t)^c r_l(t) \quad (64)$$

$$C^l(H^l(t), r_l(t)) = H^l(t) r_l(t) \quad (65)$$

With  $c > 1$ . Having defined these functional forms I can now provide some further results. First, I will define the object of interest which is the ratio of prices of a property given a location  $t$ . Consider the supply side equations (52) - (53). The ratio gives us

$$\frac{p^h(t)}{p^l(t)} = c H^h(t)^{c-1} \quad (66)$$

The specific functional form chosen leads to  $H^h(t)$  being a sufficient statistics for the ratio of prices, which is the proxy for the observed price dispersion. Higher  $H^h(t)$ , implies a higher ratio. Given lemma 2 we can already observe that the model would predict an increasing price ratio as the properties are located farther from the central business district.

I can now express the three equations defining the equilibrium values of  $H^h(t)$ ,  $H^l(t)$ ,  $p$ , and  $r_l(t)$  given  $T$ . First we can use equations (49) - (50) - (52) - (53) to obtain the following two equations

$$w - k(t) = c r_l(t) H^h(t)^c + \frac{(c r_l(t))^\sigma}{(a p)^{\sigma-1}} H^h(t)^{1+\sigma(c-1)} \quad (67)$$

$$w - k(t) = H^l(t) \left( 1 + \left( \frac{r_l(t)}{p} \right)^{\sigma-1} \right) \quad (68)$$

Lastly the indifference condition (60) leads to the following condition

$$(a p)^{\frac{\sigma-1}{\sigma}} H^h(t)^{\frac{\sigma-1}{\sigma}} + (w - k(t) - c r_l(t) H^h(t)^c)^{\frac{\sigma-1}{\sigma}} = p^{\frac{\sigma-1}{\sigma}} H^l(t)^{\frac{\sigma-1}{\sigma}} + (w - k(t) - r_l(t) H^l(t))^{\frac{\sigma-1}{\sigma}} \quad (69)$$

From this moment I will assume that the parameters are chosen as such to respect the conditions of lemma 1.

An initial result that descends directly from lemma 2 is that as the distance from the central business district the dispersion of prices increases.

### 3.6.2 Fiscal Framework

Having determined the baseline model in the previous subsection it is now possible to extend it to include a property tax. To do so, I will add a further layer, a central urban administration, which collects revenues through a property tax and redistributes them equally across households through a public good  $g$ . To simplify the computations I will define the new utility function which accounts for the public good as

$$u_g^q(x^d(t), H_q^d(t), g) = gu^q(x^d(t), H_q^d(t)). \quad (70)$$

Regarding the fiscal framework, I will setup a generic framework. Each household pays a tax  $\tau(H_q^d(t), t)$  which is a function of both housing consumption and location. An important point to stress is that the tax collectors are not able to distinguish between levels of unobservables. The problem of the household is, then

$$\begin{aligned} \text{Max}_{x_q^d(t), H_q^d(t), t} \quad & gu^q(x^d(t), H_q^d(t)). \\ \text{S.t.} \quad & w - k(t) - \tau(H_q^d(t), t) = px^d(t) + p^q(t)H_q^d(t). \end{aligned} \quad (71)$$

Which is solved when

$$\frac{p^q(t)}{p} = \frac{u_{H_q^d(t)}^q(x_q^d(t), H_q^d(t))}{u_{x_q^d}^q(x_q^d(t), H_q^d(t))} \quad \forall q \in \{h, l\} \wedge \forall t. \quad (72)$$

$$w - k(t) - \tau(H_q^d(t), t) = px_q^d(t) + p^q(t)H_q^d(t) \quad \forall q \in \{h, l\}. \quad (73)$$

The central urban administration collects the tax and uses the revenue as an input for the production of an urban public good

$$G = P_g(N, \tau(H_q^d(t), t), T). \quad (74)$$

Which is then redistributed across individuals equally

$$Ng = G. \quad (75)$$

The generality of the formulation allows for external contributions, such as transfers from the central administration or extra-fiscal revenues, or for frictions in the creation of public goods, such as administrative costs or debts.

Before moving to the three specific fiscal scenarios taken under consideration, it is important to stress two technical points regarding the modelization choices. The first one, regards the static nature of the model. The model considers consumers who face an irreversible locational choice. Agents decide once where to live and pay a form of housing ticket and the corresponding tax affects the cost of this ticket. I abstract from the choice between renting or buying a house, which is intertemporal in nature. It can be stressed that with a modelization trick it is possible to introduce some simplified form of intertemporal decision in a static world.<sup>34</sup> Consider, a situation where an agent can choose whether to buy a house or keep renting in the same location for sufficiently long time period. In this case the future expenditure weighted by the intertemporal discount factor, will be equal to the cost of a house with the same level of unobservables in the same location. If this were not the case, the agents would shift between contracts until the same utility levels are guaranteed across locations, levels of unobservables and contract types. Similarly the public good provided and the taxes due can be collapsed into a current value term.

The second one, regards the contribution of the public good. The revenues of the local administration can be redistributed in two distinct manners. One through a consumer utility input, which is different from consumption and housing, the other one simply through a redistribution of resources in the budget constraint. For the former, the modelization choice taken in this part, consider, for example, the provision of parks, roads and other local services, which are distinct from other consumption goods. This choice would be consistent with the absence of towns which decide to provide no public goods at all, something that could be possible under the second scenario. On the other hand it is important to stress that, in the setting of the paper, the effect of the public good provision on the prize of houses has to be necessarily mediated by the specific utility function adopted. Thus, it will not be easy to connect the results of the model to the pass-through debate as the capitalization will be mediated by the utility function adopted.

I will consider three scenarios: the poll tax, the location tax, and the housing consumption tax. The first one will be considered as the baseline scenario, as the change in the utility function will not allow for direct comparison with the baseline model. The three could obviously be combined but for simplicity and tractability I will consider them separately. It is important to notice, though, that the property taxes that are enacted by the states are a combination of these, the Italian one, for example, is a mix of a discrete locational tax and a housing consumption one.

The poll tax scenario has the simple following fiscal specification

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<sup>34</sup>Or expected to remain static.

$$\tau(H_q^d(t), t) = \tau. \quad (76)$$

And thus each citizen contributes equally and receives equally. The tax does not affect the price ratio directly and, thus, any effect of the tax goes through the marginal propensity to consume of agents.

A more interesting scenario is that of the location tax. Consider the following specification

$$\tau(H_q^d(t), t) = \tau(t). \quad (77)$$

Under this scenario the tax due is related to the location. Reasonably, given the current experience, we can further set the following condition

$$\frac{\partial \tau(t)}{\partial t} \leq 0. \quad (78)$$

Which in words means that, as a property is located further to the city centre, the tax due remains equal or decreasing. It is a scenario partially compatible with that of the Italian IMU, if we consider a single city<sup>35</sup>

The last type of taxation is tied to the amount of housing consumed, be it related to the size of the property (such as the number of *vani* in the Italian fiscal framework) or observable quality (such as the category and class of a property in the Italian fiscal framework). The specification would then be

$$\tau(H_q^d(t), t) = \tau(H_q^d(t)). \quad (79)$$

Given that  $q = \{l, h\}$  is not observable by the tax collector, it must be that

$$\tau(H_h^d(t), t) = \tau(H_l^d(t)) \quad \forall t. \quad (80)$$

Lastly the tax is increasing in  $H_q^d(t)$ . For simplicity I consider the following functional form

$$\tau(H_h^d(t), t) = \tau H_l^d(t) \quad \text{with } \tau \in (0, 1). \quad (81)$$

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<sup>35</sup>It might be possible that considering a commuting zone, and thus different municipalities, the fringes of the core pay lower property taxes than towns located far from the central business district. It is also important to consider that it might be the result of political choices, a topic which I am trying to abstract from at the moment.

With respect to the poll tax, the main effect will be to shift downward the income of every agent in the city equally. Given that both goods are normal goods by assumption, the tax would initially reduce consumption of the three goods, the common consumption one and the two types of housing. The equilibrium effects are less clear. In particular it is not clear the effect of an increase of income on  $p$  which depends on the first order demand effect of the two types of households and equation (69). Given that the equilibrium effect of a tax change on the level of the consumption good price  $p$  is ambiguous, there are parameters and equilibria such that an increase in the tax, actually increases the consumption in housing and consequently the price dispersion. A sufficient condition for a decreasing price dispersion is that a tax increase leads to a consumption good price decrease. This theoretical result is in contradiction with the results of both Hamilton and Zodrow, which argue that property taxes, which are a less extreme version of poll taxes, lead to less dispersion in the house prices. The main reason for this result is that, contrary to previous models, we are assuming the indifference condition (60). Compared to the previous models, the one presented here has an additional channel for internalizing changes in taxation which is households changing the type of housing consumed.

Regarding the location tax described by equation (77) the most consequence regards the interaction with lemma 2. Given a specific  $t$  the consequences of the tax is similar to the ones of the poll tax and, thus, I will not focus in it. Consider, instead, the difference between different locations across the city under consideration. Lemma 2 indicates that housing consumption increases as  $t$  increases, while the consumption good decreases. Once this locational tax is introduced there is an additional condition that must be added to lemma 2. The lemma applies if the effective income  $w - k(t) - \tau(t)$  is decreasing in  $t$ . The process is mediated by the increase in  $p^q(t)$  as the distance from the central business district increases. As the progressivity of the property tax increases and the dispersion of the effective income  $w - k(t)$  decreases, the geographic dispersion must decrease in order to maintain the indifference condition. Two cases are interesting enough to be considered individually. First there is the degenerate case under which the effective income is constant. Under this set up, the locational differences within the city are levelled out and as such  $H^q(t) = H^q$ ,  $x^q(t) = x^q$ , and  $r_l(t) = r_a$  for all  $q \in \{l, h\}$  and all  $t \in [0, T]$ . The second set up is the one under which the effective income is increasing in distance.

**Corollary 1.** *If the effective income  $w - k(t) - \tau(t)$  is increasing in the distance from the central business district, the results of lemma 2 are inverted. As such,  $p^q(t)$ ,  $r_l(t)$ , and  $x^q(t)$  are increasing in  $t$ , while the consumption of  $H^q(t)$  decreases in  $t$ .*

The third type of tax rather than affecting the effective income, it influences the price ratio between real estate properties and the consumption good captured by equations (72). As in the case of the poll tax, the effect of a change in the tax depends crucially on the changes on the consumption good price. If a positive change in the property tax leads to positive change in  $p$ , then we have a fall in  $H^d(t)$ , which, in the CES utility setting, implies a fall in the price dispersion. An opposite effect on  $p$  has more ambiguous consequences.

From these results emerges a more complicated picture than the models brought by Hamilton and Zodrow. In particular two additional channels need to be considered: the consumption price inflation and the housing type switch. The latter was one of the reasons leading to a rework of the modelling strategies regarding the study of the consequences of a property tax. On the other hand, the former was not among one of the initial motivations behind the study, but the importance of the inflation channel is self evident from the model. If we take a step back from a single city model, the influence of a property tax on the local consumption prices is a new avenue of research, with important policy consequences in particular in countries with high levels of regional inequalities such as Italy or Germany.

### 3.7 Conclusion

This chapter has two objectives. The first part aims to test the claim put forward by Hamilton and Zodrow that a property tax reduces price dispersion in a mixed community. The second one aims to bridge the real property asset literature with the urban economics and economic geography ones.

On the first front, the empirical results are consistent with the Italian property tax leading to a reduction in price dispersion. I identified the effect by exploiting the Italian policy changes adopted by the Italian governments between 2006 and 2014. These changes have enough spatial and temporal variation to allow me to identify the effect of the changes in fiscal incidence of the real estate taxation on the local property markets. The reduction in the pool of properties affected by the Italian property tax led to an increase in both maximum and minimum prices observed in the same socioeconomic zone, with a greater magnitude for higher prices. The results are robust to several different specifications and across different local property markets. The only exception seems to be the city of Milan where the policy change led to a slight decrease of the price dispersion, a result that could also be due to statistical noise given the small difference.

On the theoretical side, while the model put forward lacks the clear results of the previous works, the chapter highlights the importance of two additional channels that were ignored by previous

research. First, the model presented allows for households to switch between real estate properties of different quality. Previous work assumed the existence of two or more parallel housing consumers which interacted only through the competition for land. Second, the local price for a consumption goods bundle should be affected by the policy change and cause second order changes in the price dispersion. Summarizing, once geographical elements are included in a model, the effects of a real estate tax become wide ranging. From this second result different new questions arise, such as whether indeed consumption prices are affected by the presence of a property tax and whether the second order effects described above could explain the puzzling difference in the empirical results of Rome and Milan. Furthermore, a series of new modelization questions arise, such as a multi-city model with movement across different urban agglomerations, and dynamic models which would be able to capture the double nature of real estate properties both as a good providing utility to households and as asset. While the first extension would be useful to capture the extent of a Hamilton-Tiebout mechanism in action, the latter is a necessary step in order to tackle the rent versus buying question. Another avenue for further research would regard the public good production function. Such a model would be helpful in estimating the welfare effects of different policy designs.

The debate regarding the effects of a property tax seems stalled around old questions with no easy answer and a plethora of quasi-experimental empirical identification strategies. This chapter aims to reinvigorate the debate by connecting the previous literature with different strands of the current urban economics literature and with new modelization strategies. Further research in this strand of literature is needed to support the renovated interest in property taxes as a fiscal policy tool, such as the recent debates in Italy and Germany.

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## A Appendix Chapter 1

### A.1 Additional Figures

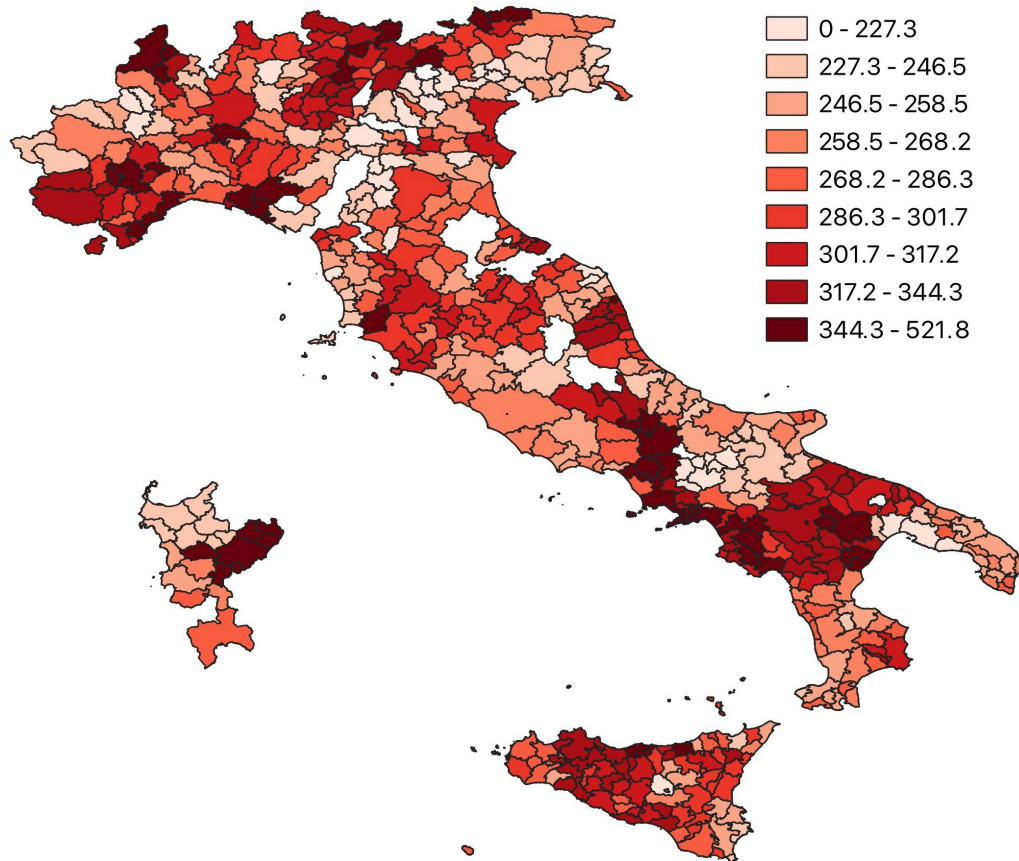


Figure 11: Weighted average of local price-to-rent ratios across different local labor markets in Italy for housing of similar quality in 2019

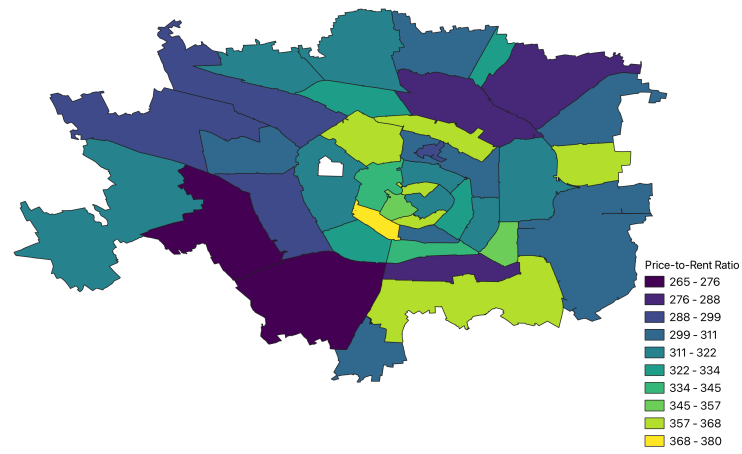


Figure 12: Local price-to-rent ratios across different neighborhoods in Milan for housing of similar quality in 2019

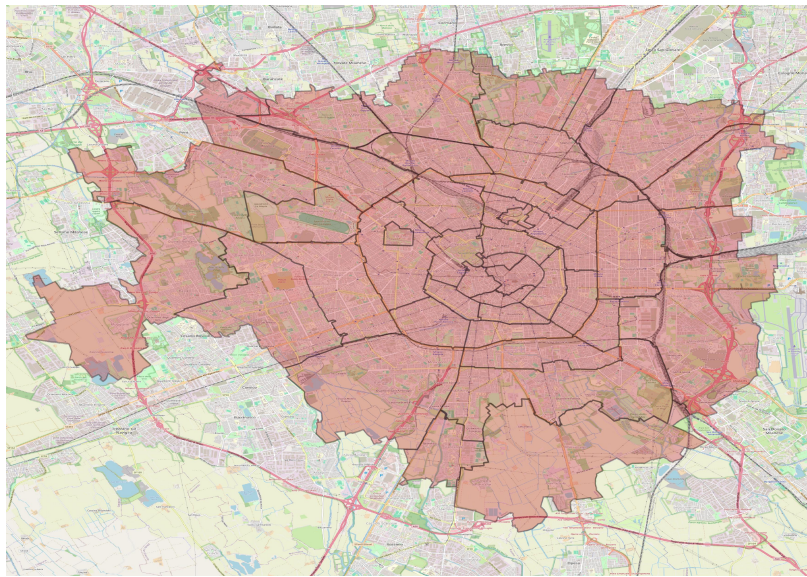


Figure 13: I plot the OMI zones for the municipality of Milan over the city map for the year 2019.

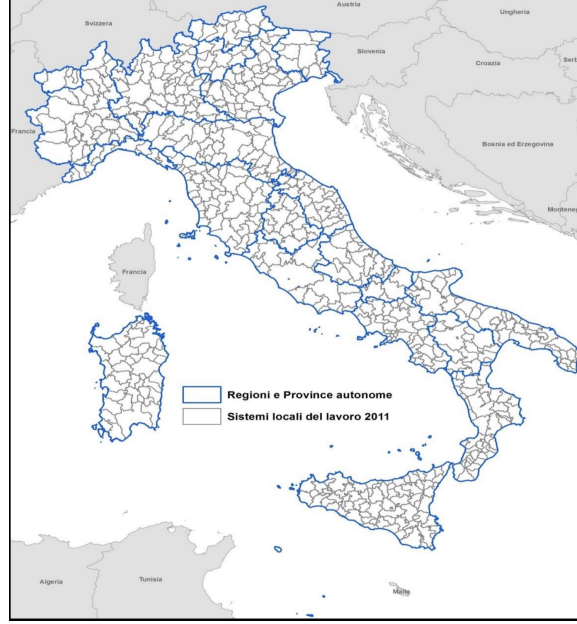


Figure 14: Istat divided the Italian territory in 612 local labor market based on local commuting patterns. The map reports the local labor markets overlayed on the administrative regional borders.

## B Appendix Chapter 2

### B.1 Model Extensions

#### B.1.1 Heterogeneous Model Extension

In this section I provide an extension to the main model with heterogeneous agents. In addition to the environment described in the theoretical section, I introduce two different populations of agents,  $Pop^H$  and  $Pop^L$ , with the only difference that they can obtain different incomes in each location such that  $w_i^H > w_i^L$  for all locations. I index the wage level by  $\iota \in \{H, L\}$ . Agents face the same problems as in the main model and the stock of housing remain homogeneous.

Thus the only difference appears in the clearing conditions, and generate a different formulation for the price-to-rent ratio:

$$\frac{(1 + \tau)p_i}{r_i} = 1 + \frac{\beta}{(1 - \phi_1)(1 + \beta)} \frac{\sum_{\iota \in \{H, L\}} w_i^\iota \text{Pop}_{i, \text{buyer}}^\iota}{\sum_{\iota \in \{H, L\}} (w_i^\iota \text{Pop}_{i, \text{renter}}^\iota + \frac{w_i^\iota}{1 + \beta} \text{Pop}_{i, \text{buyer}}^\iota)} \quad (82)$$

The price-to-rent ratio in the model extension with heterogeneous agents, is still a sufficient equation for the local relative utility between home-owners and renters. In the context of heterogeneous

agents with an income distribution, the price-to-rent ratio weighs more the utility of agents with higher income.

### B.1.2 Dynamic Formulation of the CGGVF

I will now consider the standard formulation for the CGGVF, in the context of a dynamic model. Let me consider a context where at time  $t = 0$  prices in location  $i$  are equivalent to the expected future stream of rents, due to a competitive and complete financial market. The formulation would be

$$(1 + \tau_i^0) p_i^0 = \sum_{t=0}^{+\infty} \tilde{\beta}^t r_i^t \quad (83)$$

Where I measure with  $\tilde{\beta}$  the discount rate which is equal to the safe asset interest rate  $(1 + Rate)$ . Following Amaral et al., [2023](#) and thus assuming that the households hold the shared expectation that the current local rent grows at a constant rate equal to  $g_i$  and that  $(1 + g_i) < (1 + Rate)$ , I can rearrange the equation such that

$$(1 + \tau_i^0) p_i^0 = r_i^0 \frac{1 + Rate}{Rate - g_i} \quad (84)$$

Thus I can obtain a simple formula for the current price-to-rent ratio

$$\frac{(1 + \tau_i^0) p_i^0}{r_i^0} = \frac{1 + Rate}{Rate - g_i} \quad (85)$$

The dynamic specification of the CGGVF does not alter the baseline assumption that changes in local mortgage interest rates should not be associated with changes of the left-hand side of equation [85](#).

The key assumption for the empirical estimation to hold is that the expected local growth rates of local rents does not vary, within a LLM, in a manner that is correlated with local municipal incomes.

## C Appendix Chapter 3

### C.1 Example of a Deed

I report an example of a deed which reports all the required information in order to compute the tax.

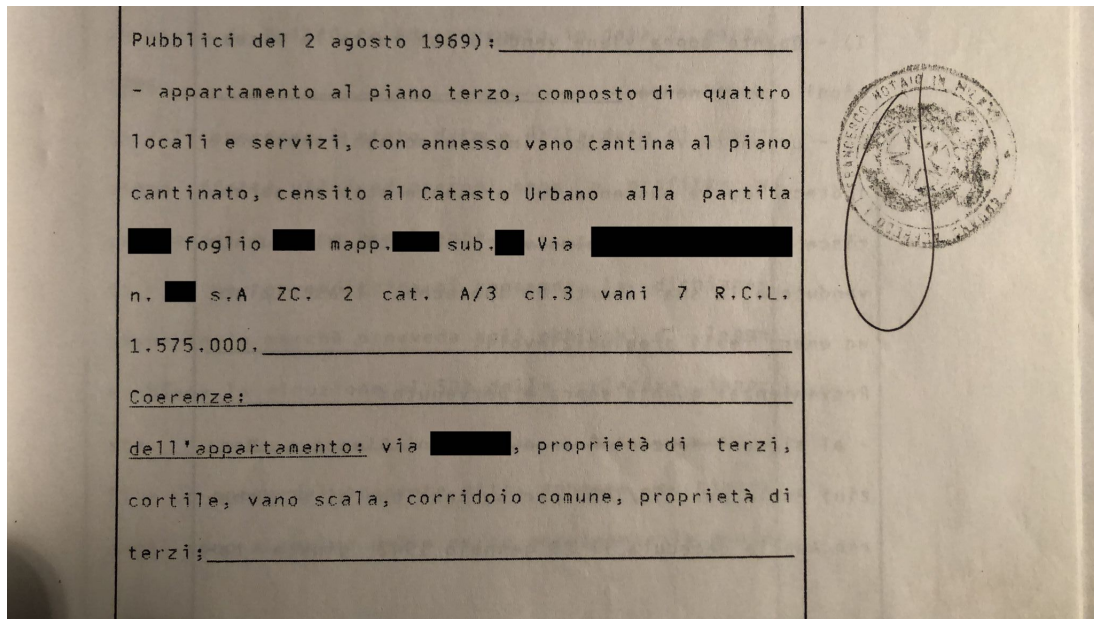


Figure 15: Example of a deed.

The deed regards an apartment in Milan. It reports the year in which it was registered (1969), the floor (third), the number of *vani* (seven) and some brief descriptions of the usage of the rooms (i.e. the presence of a cellar), the address (hidden), the cadastral maps in which it is registered, the *zona censuaria* (second of Milan), category and class (A/3 with class 3), and the equivalent value, cadastral rent, in Italian lire. It is, in fact, the deed of the example property that I have considered in the main body of the paper.

## C.2 Drawing the *Zone Censuarie*

I will report the process for drawing the *zone censuarie* with respect to two cities, Milan and Aosta, for which I received different types of information. With respect to Milan, the provincial office of the cadastre sent me the following map.



| MILANO                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Zona censuaria 1.</b> | A giro da Nord verso Est: via Paolo Sarpi, piazza Balamonti, viale Pasubio, viale Monte Grappa, viale Monte Santo, piazza Repubblica, viale V. Veneto, viale Piave, viale Premuda, piazza 5 Giornate, viale Montenero, piazza Medaglia d'Oro, viale Sabotino, viale Bligny, viale Col di Lana, piazza XXIV Maggio, via Gorizia, viale Coni Zugna, piazza Aquileia, viale San Michele al Carso, piazzale Beracca, via Mario Pagano, piazzale Sempione, via Bertani, via Canonica.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Zona censuaria 2.</b> | A giro da Nord verso Est: da via Tribuniano seguendo la linea ferrata fino alla stazione di Lambrate e oltre fino al sottopassaggio di viale Puglie, via I.lli Roselli, via Avezzana, piazzale G. Rosa, viale Omero, via Dionigi, piazza Angliberto, via M. D'Agrate, via B. Quaranta, via G. Ripamonti dal civico 154 fino a viale Toscana, viale Tibaldi, via Fedro, via Alcardo, via G. Carcano, via Cristoforo Gandino, via Rimini, via Moncucco fino al civico 20, linea ferrata oltre il Naviglio Grande fino a piazza Tirana, via Inganni, via Forze Armate dal civico 163 al civico 179, via Oliveri, via Cardinale Tosi, via Domokos, piazza Amati, via Novara fino al civico 92 verso piazza Auxum, via Piccolomini, via Feltoni, via Centauro oltre l'ippodromo, via Diomede, via A. Sanf'Elia, via Vigorelli, piazza Kennedy, a Nord verso via De Gasperi fino a via Calandra, via Landolfo 2° da Carcano, via Serretta fino alla linea ferrata. |
| <b>Zona censuaria 3.</b> | Restante territorio comunale.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| SAN DONATO MILANESE      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Zona censuaria 1.</b> | Tutto il territorio a Est della via Emilia, con esclusione della parte compresa tra le vie: 2 Giugno, via Ferrandine (parte), via Primo Maggio, via Comunale Bolgiano Monticello e il comune di Peschiera Borromeo, che insieme alla parte Ovest della via Emilia, formano la 2° Zona censuaria.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

— A 13 —

Figure 16: Map of the three *zone censuarie* and the streets of the boundaries

The picture is a map provided as an attachment to the internal journal of the Italian tax authority "*Il Fisco*" in 1992 to ease the local implementation of the ISI. When provided by the local cadastral offices, it was the easiest option to digitalize.

With respect to Aosta the local authority sent me a list of the cadastral parcels tied to each of the three *zone censuarie* as shown in the next picture.

### AOSTA

Z.C. 1 - 25 - 33 - 34 - DAL 38 AL 46 - 59 - 60  
Z.C. 2 - DAL 1 AL 24 - DAL 26 AL 30 - DAL 47 AL 57  
Z.C. 3 - 31 - 32 - 35 - 36 - 37 - 58 - 61 - 62

Figure 17: List of cadastral parcels per *zona censuaria* in Aosta.

Having these I can use the geospatial tool provided by the cadastre to map the three *zone censuarie* as in the following figure.

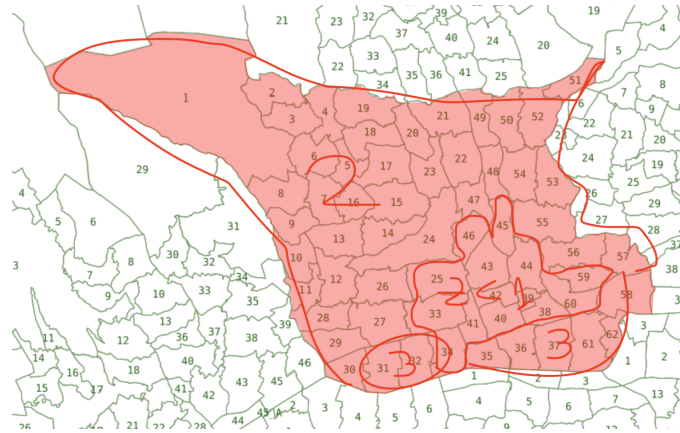


Figure 18: The different *zone censuarie* of Aosta.

Having, in both cases, a map of the *zone censuarie* it is then possible to draw them on QGIS. Figures 19 and 20 report the final results.

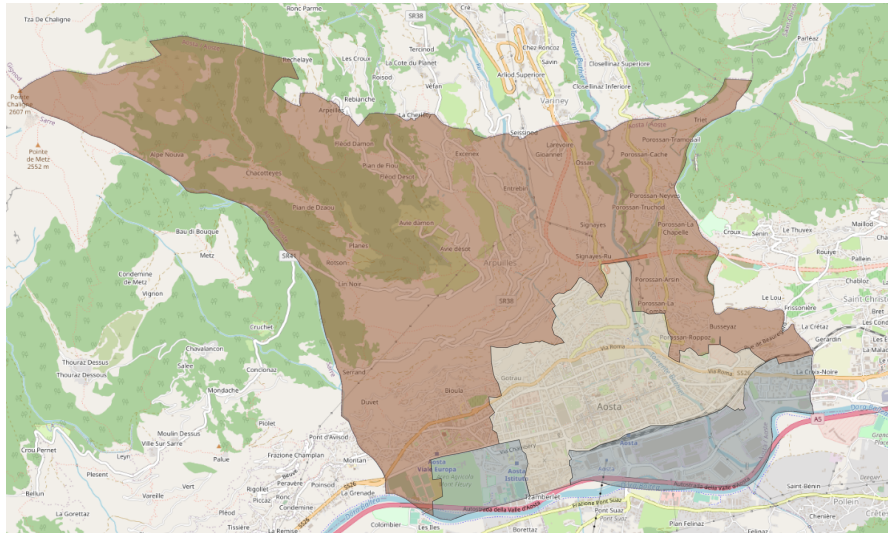


Figure 19: *Zone Censuarie* of Aosta.

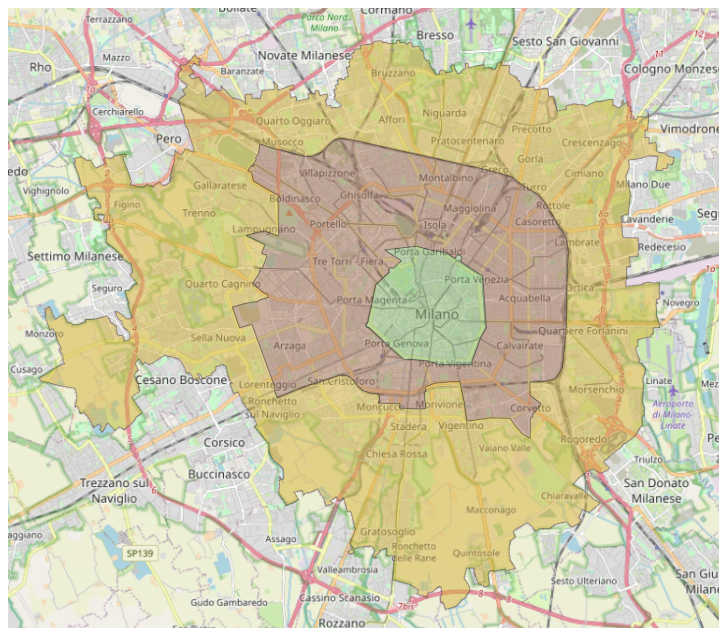


Figure 20: *Zone Censuarie* of Milan.

Superimposing the newly obtained maps of the *zone censuarie* and the polygon shapes of the OMI areas provided by the Osservatorio del Mercato Immobiliare, it is then possible to assign to

each OMI area the corresponding *zona censuaria* and thus some estimate of the local property tax.

### C.3 Additional Results per City

#### C.3.1 Policy Impact on Individual Cities

In the following subsection I show the individual results of the policy impact analysis on the four main cities in the sample. Figures 21 and 22 report the results for Rome, figures 23 and 24 report the results for Milan, figures 25 and 26 reports the result for Turin, and, lastly, figures 27 and 28 report the results for Palermo.

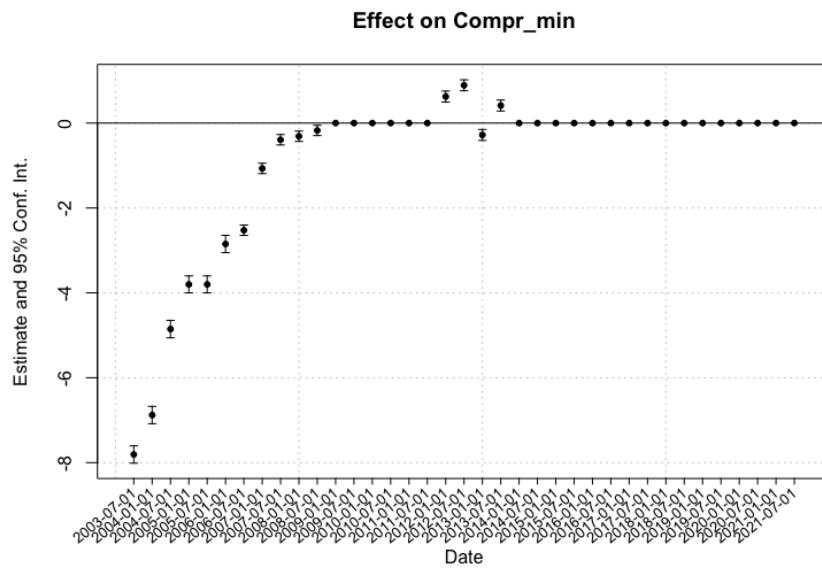


Figure 21: Policy impact on the lower bound for Rome.

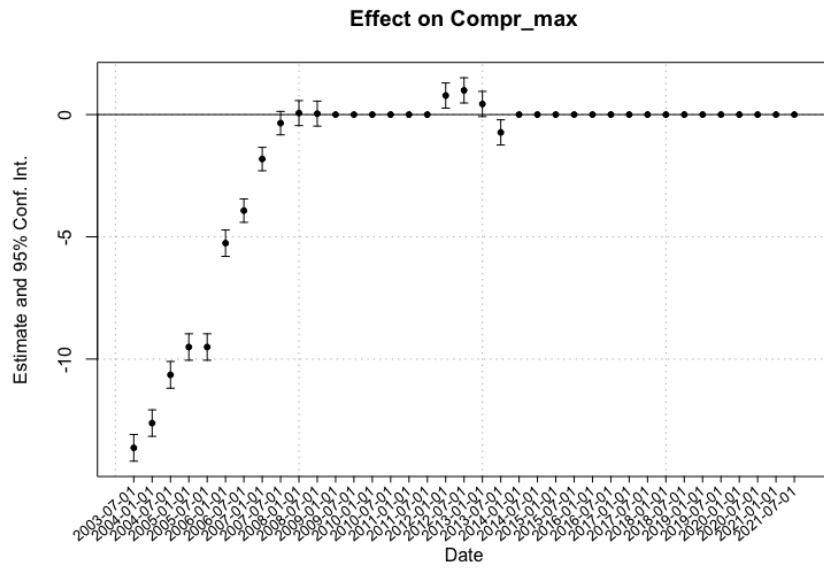


Figure 22: Policy impact on the upper bound for Rome.

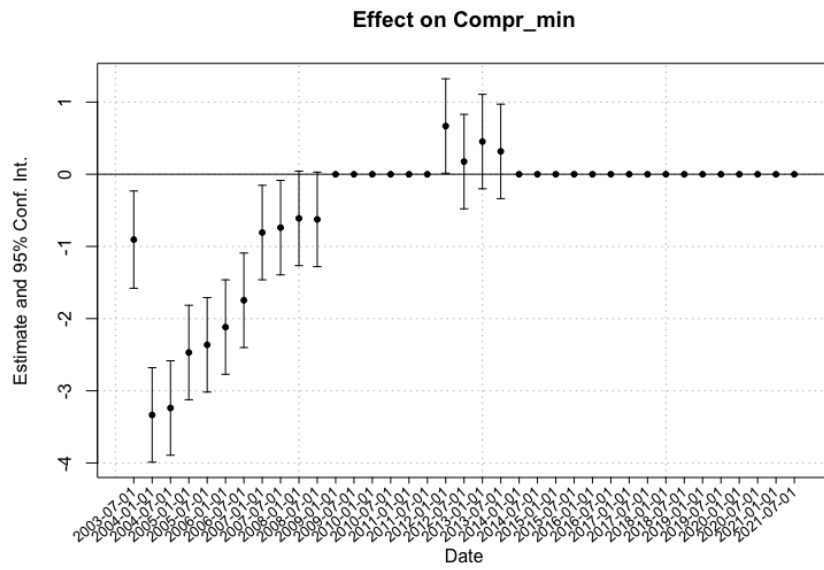


Figure 23: Policy impact on the upper bound for Milan.

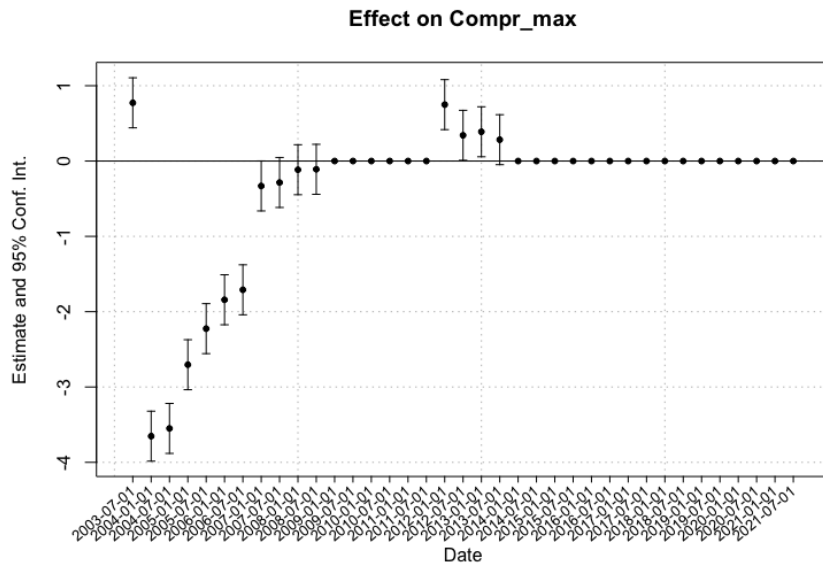


Figure 24: Policy impact on the upper bound for Milan.

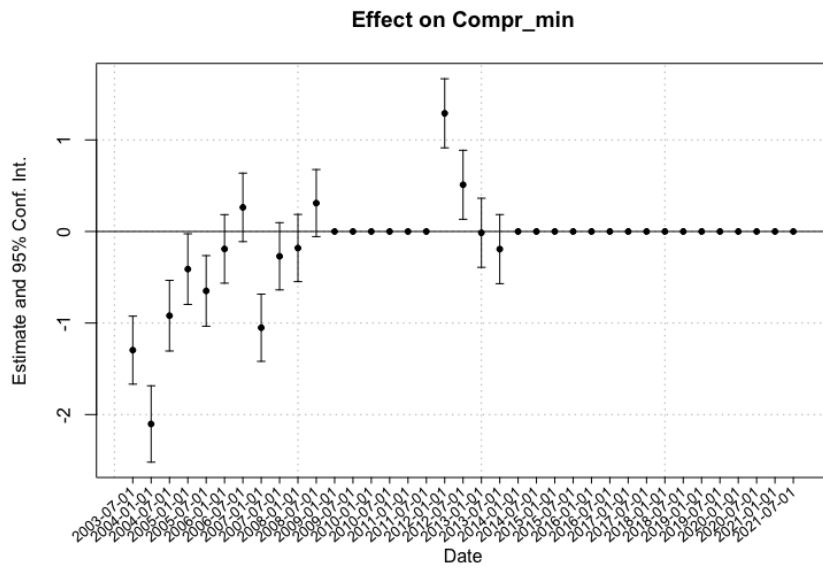


Figure 25: Policy impact on the lower bound for Turin.

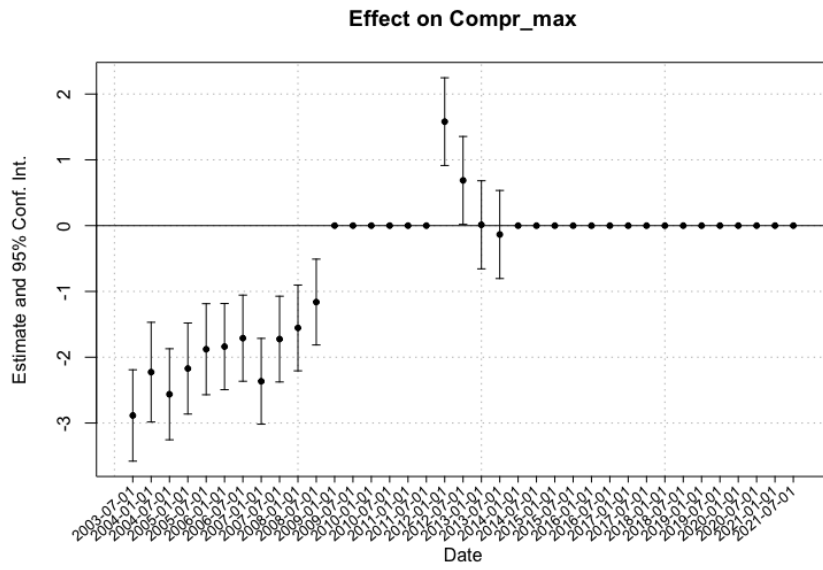


Figure 26: Policy impact on the upper bound for Turin.

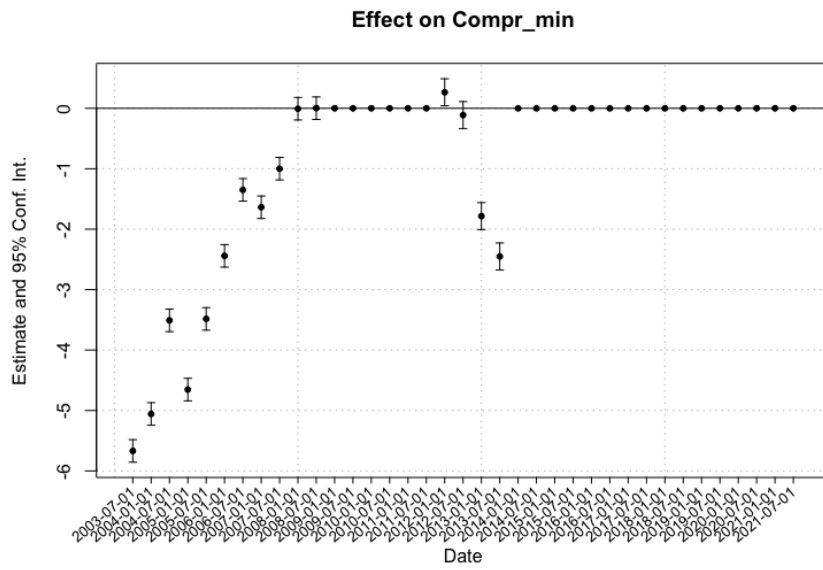


Figure 27: Policy impact on the lower bound for Palermo.

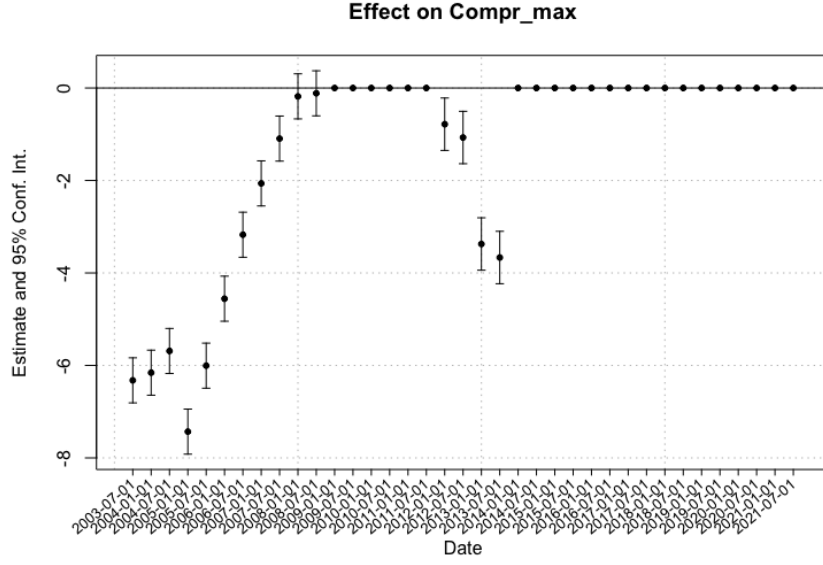


Figure 28: Policy impact on the upper bound for Palermo.

### C.3.2 Robustness Checks on Individual Cities

In tables [31](#) and [32](#) I report the result of regression [33](#) when applied to a specific municipal subsample. As in tables [23](#) and [24](#), odd columns report the coefficient for the lower bound, while even columns report the result for the upper bound. Columns (1) and (2) of table [31](#) refer to Rome, columns (3) and (4) of the same table refer to Milan, columns (1) and (2) of table [32](#) refer to Turin, and, lastly, columns (3) and (4) of the latter table refer to Palermo.

| Prices                  | (1)       | (2)       | (3)       | (4)       |
|-------------------------|-----------|-----------|-----------|-----------|
| <i>Tariffa d'estimo</i> | −1.461*** | −2.876*** | −1.169*** | −1.011*** |
|                         | (0.178)   | (0.272)   | (0.201)   | (0.331)   |
| N                       | 5091      | 5091      | 3356      | 3356      |
| R <sup>2</sup>          | 0.979     | 0.973     | 0.970     | 0.955     |
| Quality FE              | No        | No        | Yes       | Yes       |
| City                    | Rome      | Rome      | Milan     | Milan     |
| Bound                   | Lower     | Upper     | Lower     | Upper     |

Table 31: Table of Results: Rome and Milan (2003-2013).

| Prices                  | (1)     | (2)     | (3)       | (4)       |
|-------------------------|---------|---------|-----------|-----------|
| <i>Tariffa d'estimo</i> | −0.321  | −1.191* | −2.130*** | −3.381*** |
|                         | (0.469) | (0.677) | (0.533)   | (0.721)   |
| N                       | 961     | 961     | 990       | 990       |
| R <sup>2</sup>          | 0.912   | 0.918   | 0.963     | 0.962     |
| Quality FE              | Yes     | Yes     | No        | No        |
| City                    | Turin   | Turin   | Palermo   | Palermo   |
| Bound                   | Lower   | Upper   | Lower     | Upper     |

Table 32: Table of Results: Turin and Palermo (2003-2013).