Mortgage Rates and the Price-to-Rent Ratio Across Space*

Alberto Nasi†

October 10, 2025

[Latest Version]

Abstract

This paper develops a parsimonious housing market model that conceptualizes residential real estate as both a non-tradable consumption good and an investment asset. The framework embeds households' joint location–tenure choices, which shape local price-to-rent ratios. I test its predictions using a granular dataset of Italian housing prices and rents and a shift-share instrumental variable design exploiting heterogeneity in mortgage uptake across age groups. The results show that mortgage rate shocks induce spatially asymmetric responses in prices, rents, price-to-rent ratios, population, and tenure choices, consistent with the implications of the model. A structural estimation reproduces these heterogeneous effects and indicates that a positive mortgage rate shock alleviates spatial welfare inequality and narrows the divide between renters and homeowners.

JEL Codes: E22, G12, G21, R21, R23, R31

*I am grateful to Jan Bakker, Italo Colantone, Marta Prato, and Gianmarco Ottaviano for their patient guidance. I thank Sara Bagagli, Victor Sancibrián, Marta Santamaria, Nikodem Szumilo, and Tuuli Vanhapelto for their helpful comments. Lastly, I thank the participants to the 13th Meeting of the Urban Economic Association, the Bocconi Trade Tea, the 2024 Urban Economic Association Summer School, and the 1st Zurich–Oxford Doctoral Symposium on Real Estate Markets for all the insightful discussions. Any omission or error is my own.

†Department of Economics, Bocconi University. Email: alberto.nasi@phd.unibocconi.it. Site: Alberto Nasi

1 Introduction

Households hold real estate assets for two distinct purposes. The first is to satisfy their demand for housing services, which can be met either through participation in the rental market or via owner-occupation. The second reflects an investment motive, whereby housing is acquired as a financial asset generating a return equal to the rental yield.

This dual nature of housing gives rise to two different interpretations of the price-to-rent ratio for residential properties. The first interpretation, which I refer to as the *financial interpretation*, relies on the asset nature of residential properties. From this perspective, an investor may acquire a property to supply on the rental market, viewing the purchase price as the cost of investment and the expected stream of rents as the associated returns. In real estate markets, price-to-rent ratios correspond, then, to the capitalization rate, which measures the return on a real estate investment. A lower capitalization rate indicates higher expected returns relative to the cost of the asset. In its simplest formulation, often formalized through the Gordon Growth Valuation Formula, under the assumptions of no-arbitrage conditions and a reasonably competitive market, the asset price should be equal to the expected stream of rents, net of the operating costs.

The second interpretation, which I label as the *relative preference interpretation*, builds on the consumption aspect of housing for both home-owners and renters. In this view, households interpret the price-to-rent ratio as a signal in the tenure choice, buying versus renting, where a lower ratio implies that purchasing is relatively more advantageous than renting. If buyers and renters have heterogeneous demand functions for housing, variations in the local composition of owners and tenants may themselves drive observed differences in price-to-rent ratios.

Both interpretations must account for the pronounced spatial heterogeneity observed in price-to-rent ratios.[1] Recent theoretical and empirical frameworks that seek to explain this heterogeneity have predominantly adopted the financial interpretation, attributing local variation either to differences in expectations about future fundamentals or to local wedges between the transaction and rental markets.

In this paper, I demonstrate that the standard Gordon Growth Valuation Formula alone cannot fully account for the spatial patterns in price-to-rent ratios. I further propose an augmented version of the formula that incorporates the relative preference interpretation of price-to-rent ratios, thus capturing local market dynamics through the spatial and tenure reallocation of households.

[1] In the appendix I provide two maps of spatial variation, respectively 4 for the variation across different local labor markets and 5 for the variation within the municipality of Milan.

To define the augmented version of the price-to-rent ratio, I develop a static spatial model in which agents simultaneously choose their location and tenure status. Housing units are supplied by a construction sector, while home-owners, after determining the optimal quantity of housing assets to purchase, decide what share of their holdings to supply to the rental market. Home-owners, thus, derive utility from three sources: the direct consumption of housing services, the additional income generated by renting out part of their property, and an ownership-related utility component akin to the warm-glow bequest motive featured in the wealth distribution literature. The augmented version of the Gordon Growth Valuation Formula captures both the financial and the relative preference interpretations of price-to-rent ratios. Under specific functional assumptions, equilibrium prices in the model are equal to rents plus an additional term that depends on the local share of home-owners. In this framework, the price-to-rent ratio emerges as a sufficient statistic for local relative welfare between home-owners and renters.

To empirically assess the standard Gordon Growth Valuation Formula, I exploit exogenous variation in local mortgage rates and its impact on both prices and rents. The standard formulation predicts that the local response of price-to-rent ratios should be constant and equal to zero. As the cost of housing goes up, prices fall and rent increase, in order to maintain the no-arbitrage condition between the two markets. By contrast, the augmented version of the formula implies that a spatial and tenure reallocation of households may generate an ambiguous response of the price-to-rent ratio. In this framework, shifts in local composition and tenure decisions can attenuate, or even reverse, the mechanical adjustment predicted by the classical model.

Two main challenges emerge in the empirical literature when estimating the relationship between mortgage rates, housing prices, and rents. The first concerns selection into market segments: residential properties are not randomly allocated between the rental and ownership markets. Lower-quality units tend to be disproportionately supplied for rent, making it difficult to compare equivalent properties across the two markets. To address this issue, I exploit a rich dataset compiled by the Italian Fiscal Agency, which administers the national cadaster and oversees all property and rental contracts. The dataset contains detailed information on both prices and rents for properties of varying quality and use across the entire country. This unique feature allows me to compare housing units of similar characteristics within the same sub-municipal areas, thereby mitigating concerns related to non-random supply and quality differences.

The second challenge concerns the endogeneity among prices, rents, and local mortgage rates, which precludes consistent estimation of their causal relationships. To overcome this issue, I employ a shift-share instrumental variable strategy. The share component exploits variation in mortgage uptake rates across age groups: younger households are substantially more likely to finance purchases with mortgages than older ones. Consequently, two otherwise similar municipalities, one predominantly composed of residents aged over 70 and another dominated by individuals aged 30 to 50, will respond differently to changes in mortgage rates. The younger location will be more sensitive to a mortgage interest rate shock. The shift component is constructed by instrumenting local regional mortgage interest rates with a composition of Eurozone mortgage rates, isolating continent-wide supply side financial shocks, thus isolating an exogenous and quasi-randomly distributed source of variation. This approach enables credible identification of the causal effects of mortgage rate shocks on both housing prices and rents.

Empirically, I find that the local price-to-rent ratios, when accounting for local mortgage interest rates, do respond to a mortgage rate shock, a result that contradicts the predictions of the Classical Gordon Growth Valuation Formula. Specifically, there exists substantial spatial heterogeneity in both the magnitude and direction of these responses. Moreover, the reactions of prices and rents are highly asymmetric across locations: some areas experience simultaneous declines in both prices and rents, while others exhibit increases in both. These heterogeneous responses are not consistent with a framework in which agents do not reallocate themselves across space and tenure status or a world in which price-to-rent ratios are described exclusively by the standard Gordon Growth Valuation Formula. Consistent with the reallocation hypothesis, I further document that agents adjust both location and tenure status in response to a national mortgage rate shock.

Finally, to further validate the model and assess the potential welfare implications of a mortgage interest rate shock, I conduct a structural estimation aimed at isolating the effects of the increase in mortgage interest rate observed between 2021 and 2023. The model successfully reproduces the observed dispersion in the responses of housing prices, rents, price-to-rent ratios, and tenure choices documented in the empirical analysis. Moreover, the estimation suggests that the nationwide mortgage rate hike over this period contributed to a reduction in spatial disparities as well as in welfare inequalities between home-owners and renters.

The paper is divided into seven sections, including the present introduction. Section 2 reviews the existing literature on the price-to-rent ratio. Section 3 outlines the theoretical framework and introduces the augmented Gordon Growth Valuation Formula, which also provides the testable implications of the standard formulation. Section 4 describes the data and the empirical identification strategy. Section 5 presents the main results of the empirical analysis. Section 6 develops the structural estimation of the model and conducts a counterfactual exercise to evaluate the distributional consequences of a mortgage rate hike comparable to the one experienced in Italy between 2021 and 2023. Section 7 provides concluding remarks.

2 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 relationship between mortgage rates, prices, and rents, and the third on the spatial distribution of housing prices.

When price-to-rent ratios and the underlying tenure choice was approached by economists in the US, see Henderson and Ioannides, 1983 and Poterba, 1984, it revolved around the specific nature of the US tax system and the no arbitrage condition for the residential property asset. Following Gordon and Shapiro, 1956 papers have equated the price of the asset to a function of the expected stream of rents and the local wedges. As examples, with different set up, see Krainer and LeRoy, 2002, Campbell, Davis, Gallin, and Martin, 2009, Sommer, Sullivan, and Verbrugge, 2013, and Favilukis, Ludvigson, and Van Nieuwerburgh, 2025, which all provide equilibrium formulas that are consistent with the Classical Gordon Growth Valuation Formula. In this context the present papers augments the formula for price-to-rent ratios, thus providing an additional mechanism for their spatial heterogeneity. 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, Hacihasanoğlu, and Yılmaz, 2023. In this context the present research finds that a change in mortgage interest rates causes a heterogeneous response in both prices and rents which are both positively correlated with local wages. In other words, richer and more populous cities experience higher responses in prices and rents than poorer and less populous ones.

The last contribution regards the distribution of prices and how to model housing market in a quantitative spatial model. 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).

There is a trade-off in the literature between a dynamic model and a spatial one, in particular with regards to the topic of capital accumulation. The assumptions taken to maintain tractability are either not consistent with a joint location-tenure choice, as in Kleinman, Liu, and Redding, 2023, or assume directly the Classical Gordon Growth Valuation Formula, as in Van Nieuwerburgh and Weill, 2010, Vanhapelto, 2022, and Greaney, Parkhomenko, and Van Nieuwerburgh, 2025. This paper focuses on maintaining the joint location-tenure choice with a less stringent formulation for the price-to-rent ratio. In this manner I am able to provide an additional interpretation of price-to-rent ratio as a sufficient statistic for the local relative welfare of renters and home-owners.

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. In this research I leverage a granular Italian dataset of local prices and rents, which takes into account the different quality levels allowing me to correctly compare properties of similar quality. With respect, instead, to the correct identification of the causal effect of mortgage interest rates on prices and rents, in order to test the Classical Gordon Growth Valuation Formula, I leverage a novel SSIV identification strategy. In particular, I follow the SSIV interpretation of Borusyak, Hull, and Jaravel, 2022, with state of the art control as highlighted by Almuzara and Sancibrián, 2025 and Hahn, Kuersteiner, Santos, and Willigrod, 2025, which relies on the quasi-random distribution of shocks, to drive the identification.

3 The Model

Standard models with housing tenure choices and locations imply the no arbitrage condition, the Classical Gordon Growth Valuation Formula (CGGVF), between home-ownership prices versus rents.

$$(1 + \tau_i)p_i = r_i \tag{1}$$

The financial implication the the CGGVF is that the consumer price of the housing asset, the left-hand side in equation 1, is equal to the expected stream of rents, the right-hand side of the same equation.

$$\frac{p_i}{r_i} = \frac{1}{1 + \tau_i} \tag{2}$$

Where p_i is the local housing prices, r_i is the expected stream of rents, and $(1 + \tau_i)$ is measure of wedges between the two different markets. In the context of the current paper the main wedge between the two are the mortgage repayments for home-owners, which increase the cost of housing with respect to rent.

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. In the OLS regression in table 1 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.[2] 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.

[2] 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.

	National	South	North	Income $<$ Median
	Price-to-Rent	Price-to-Rent	Price-to-Rent	Price-to-Rent
Log of Income	0.0665^{***}	0.0814^{**}	0.0627^{***}	0.433^{***}
	(0.0178)	(0.0354)	(0.0143)	(0.0155)
Interest Rates	-0.0482	-0.229^{***}	0.115^{**}	0.112^{***}
	(0.0296)	(0.0689)	(0.0463)	(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 1: 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 descend from the financial interpretation of the 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 an augmented version of the Gordon Growth Valuation Formula, which accounts for the relative utility preferences.

3.1 Functional Form

I define a static model where $Pop \in \mathbb{R}_+$ agents face a simultaneous location-tenure choice. There exists I different locations indexed by $i \in \{1, \ldots, I\}$ 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.[3] 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:

$$\begin{aligned} Max_{c_i, H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1-\phi_1) \log H_i^c \\ s.t. \quad & w_i = r_i\, H_i^c + c_i \\ & H_i^c,\, c_i \geq 0 \end{aligned} \tag{3}$$

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

$$\begin{aligned} Max_{c_i, H_i, H_i^r, H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1-\phi_1) \log (\mu_i H_i^c) + \beta \log H_i. \\ s.t. \quad & w_i + r_i H_i^r = (1+\tau) p_i\, H_i + c_i. \\ & H_i^c + H_i^r = H_i. \\ & H_i,\, H_i^r,\, H_i^c,\, c \geq 0. \end{aligned} \tag{4}$$

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. 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.

[3] 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.

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 μ_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 β. It is possible to rearrange the budget constraint of the home-owner problem such that:

$$\begin{aligned} Max_{c_i,H_i,H_i^r,H_i^c} \quad & \log A_i + \phi_1 \log c_i + (1-\phi_1)\log\left(\mu_i H_i^c\right) + \beta \log H_i. \\ s.t. \quad & w_i = \left((1+\tau)p_i - r_i\right) H_i + r_i\, H_i^c + c_i. \\ & H_i^c,\, c_i \geq 0 \quad H_i \geq H_i^c. \end{aligned} \tag{5}$$

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:

$$c^*_{i,renter} = \phi_1\, w_i,\; H^{c^*}_{i,renter} = \frac{1-\phi_1}{r_i} w_i. \tag{6}$$

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

$$c^*_{i,buyer} = \frac{\phi_1}{1+\beta}\, w_i,\; H^{c^*}_{i,buyer} = \frac{1-\phi_1}{1+\beta}\frac{w_i}{r_i},\; H^*_{i,buyer} = \frac{\beta}{1+\beta}\frac{w_i}{(1+\tau)p_i - r_i}. \tag{7}$$

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 4:

$$(1+\beta) r_i \geq (1-\phi_1)(1+\tau) p_i. \tag{8}$$

The higher the investment return of the asset, r_i, and the home-ownership additional utility for home-owners, β, 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, ϕ_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 σ_t and the inverted location elasticity as σ_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 λ_i:

$$\lambda_{t|i} = \frac{\exp U_{t,i}{}^{\frac{1}{\sigma_t}}}{\sum_{k\in\{buyer,renter\}} \exp U_{k,i}{}^{\frac{1}{\sigma_t}}}. \tag{9}$$

Similarly:

$$\lambda_i = \frac{\left(\sum_{k\in\{buyer,renter\}} \exp U_{k,i}{}^{\frac{1}{\sigma_t}}\right)^{\frac{\sigma_t}{\sigma_l}}}{\sum_{j=0}^{I}\left(\sum_{k\in\{buyer,renter\}} \exp U_{k,j}{}^{\frac{1}{\sigma_t}}\right)^{\frac{\sigma_t}{\sigma_l}}}. \tag{10}$$

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

$$\lambda_{i,t} = \lambda_i \, \lambda_{t|i}. \tag{11}$$

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:

$$Max_n \quad p_i H_i^s - w_i n - \bar{p}_i \bar{H}_i. \tag{12}$$

$$s.t. \quad H_i^s = n_i^{\rho} \bar{H}_i^{1-\rho_i}. \tag{13}$$

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. ρ_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:

$$H_i^s = \left(\frac{\rho_i\, p_i}{w_i}\right)^{\frac{\rho_i}{1-\rho_i}} \bar{H}_i \tag{14}$$

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 $\{p_i, r_i\}_{i\in\{1,\ldots,I}$ 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:

$$H_i^s = Pop_{i,buyer} \frac{\beta}{1+\beta} \frac{w_i}{(1+\tau)p_i - r_i} \tag{15}$$

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

$$Pop_{i,buyer}\left(\frac{\beta}{1+\beta}\frac{w_i}{(1+\tau)p_i - r_i} - \frac{1-\phi_1}{1+\beta}\frac{w_i}{r_i}\right) = Pop_{i,renter}\frac{1-\phi_1}{r_i} w_i \tag{16}$$

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

$$(1+\tau)p_i = r_i + \frac{w_i}{H_i}\frac{\beta}{1+\beta} Pop_{i,buyer}. \tag{17}$$

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.[4]

[4] 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:

$$(1+\tau)p_i = \frac{w_i}{H_i^s}\left((1-\phi_1)Pop_{i,renter} + \frac{1-\phi_1+\beta}{1+\beta}Pop_{i,buyer}\right) \tag{18}$$

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:

$$r_i = \frac{w_i}{H_i^s}\left((1-\phi_1)Pop_{i,renter} + \frac{(1-\phi_1)}{1+\beta}Pop_{i,buyer}\right) \tag{19}$$

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.

$$\frac{(1+\tau)p_i}{r_i} = 1 + \frac{\beta}{(1-\phi_1)(1+\beta)}\frac{\mathrm{Pop}_{i,\mathrm{buyer}}}{\left(\mathrm{Pop}_{i,\mathrm{renter}} + \frac{1}{1+\beta}\mathrm{Pop}_{i,\mathrm{buyer}}\right)}. \tag{20}$$

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 20, accounting for the fact that $Pop_{t,i} = \lambda_i\, \lambda_{t|i} Pop$:

$$\frac{(1+\tau)p_i}{r_i} = 1 + \frac{\beta}{(1-\phi_1)(1+\beta)}\frac{1}{\left(\lambda_{\mathrm{renter}|i}/\lambda_{\mathrm{buyer}|i} + \frac{1}{1+\beta}\right)}. \tag{21}$$

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 1.

4 Data and Empirical Strategy

The aim of the empirical section of the paper is to validate the model with respect to the CGGVF, in particular with respect with local mortgage rate shocks. In fact the standard no arbitrage condition implies that

$$\frac{\partial (1+\tau)p_i/r_i}{\partial \tau} = 0. \tag{22}$$

Furthermore, if there are no location-tenure readjustments by the households, the model implies a null or negative correlation in local responses of both prices and rents. In fact, once if there is no supply side reduction in housing, then rents should not be affected by a mortgage rate shock. In that case, as τ increases, p_i should decline in order for equation 22 to hold. On the other hand, if there is a supply side reduction (as the wedge between buyers and builders widens) given a fall in local prices, then rents should increase due to the reduction in H_i^s. The opposite is true if local supply of housing increases.

On the other hand, the AGGVF can take into account possible deviations from equation 22, by taking into account the spatial and tenure reallocation of agents.

It is then possible to test whether the CGGVF holds, by estimating the local causal effect of mortgage rate shocks on both prices, rent and price-to-rent ratios.

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 between prices, rents, and price-to-rent ratios and the the local mortgage interest rates. In the next paragraph I'll show how this paper solves both in a novel way.

The historical problem of working with data regarding the price-to-rent ratios revolves around 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 goods. In order to avoid the issue I leverage a novel 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.[5]

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.

[5] Real estate property transactions and rental contracts, for period that are above 30 days, are required to be registered in the Italian cadastre by law.

I recover the 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. By law all real estate transactions have to be registered at the cadaster as most rental contracts.[6] 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.[7] 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.[8] 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.

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 7.

4.1 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:

[6]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.

[7]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 bounds.

[8]As an example, I report in the appendix figure 6 the OMI zones for 2019 in Milan overlayed on the city map.

$$\log y_{i,t,q} = \alpha + \beta \log \tau_R + \gamma_m + \gamma_{LLM,t} + \gamma_q + \varepsilon_R. \tag{23}$$

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 τ_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 residential properties prices and rents. To do so we need an identification strategy to overcame the potential endogeneity. I will leverage an instrumental variable shift-share approach (SSIV).

A shift-share regression relies on different levels of exposure to a shock by different groupings of observations. There are two interpretations of the SSIV 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, that the shocks are mutually uncorrelated given the unobservable, 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. In addition to these lifecycle considerations, several Italian banks have policies of not awarding mortgages to households that would finish repaying after turning a specific age (often between 70 and 80) or require an additional life insurance.

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 2: Distribution of buyers per age class who take a mortgage when buying a residential property. Source: Ghiraldo and Marignoli, 2023, published by the OMI, based on transaction level data.

Given the observed data, it is reasonable to assume that in municipalities with a younger population, buyers will be more likely to be affected by shifts in mortgage rates. Consider, in this sense, two 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.[9] In figure 1 one can observe that the younger population is concentrated in the Po Valley in the north, around Rome in the center, and around the main urban areas in the south. Conversely, the older Italian population is concentrated in mountainous areas across the country.

[9]The quasi-random shock interpretation of the SSIV allows for endogenous local shares.

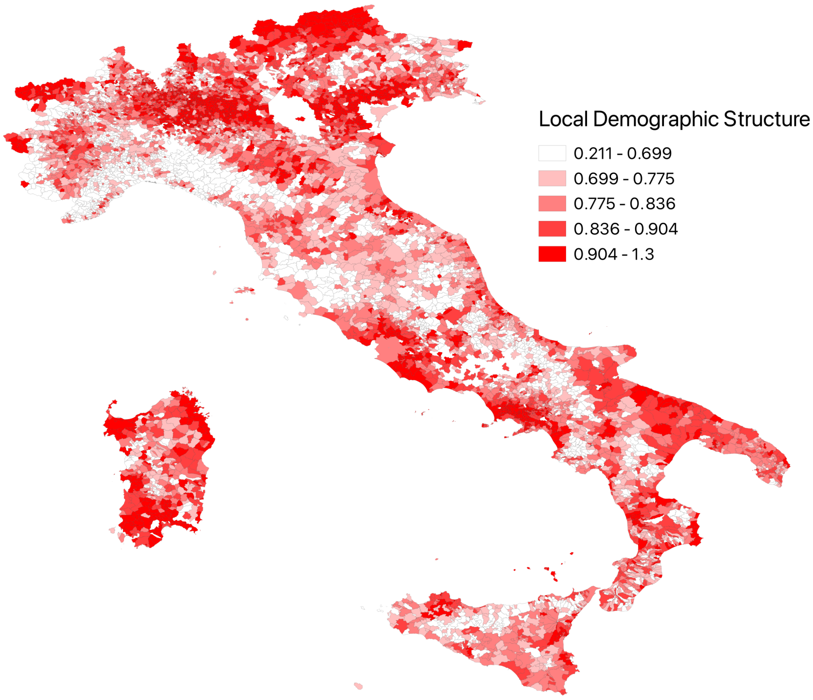

Figure 1: Map of Italian municipalities highlighted on the rate of 18-50 years old residents with respect to everyone else.

I will use the rates in table 2 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 3 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 3: Share of buyers of a spefic age class. Source: Ghiraldo 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:

$$e_m = \sum_a s_{m,a}\, t_a \tag{24}$$

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 2. 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 is:

$$\log y_{i,t,q}^{e_i} = \alpha + \beta \log {\tau_R}^{e_m} + \gamma_i + \gamma_{LLM,t}^{s_m} + \gamma_q^{s_m} + \varepsilon_R. \tag{25}$$

Where the superscript e_m indicates the variable is interacted with the exposure shares and the superscript s_m 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 this context, 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 β 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, Dorn, and Hanson, 2013. I construct an index of Eurozone commercial mortgage rates with which 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 local 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 25 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.

The theoretical prediction of the CGGVF, as seen in 22, is that the price-to-rent, including the mortgage interest rate, should be invariant to exogenous changes to the mortgage interest rates.

The regression analysis described in equation 25 should capture the aggregate effect of mortgage interest rates on local prices and rents. The price-to-rent ratio described in equation 20, though, implies that different locations will respond differently to the same local mortgage rate shock. To account for this I introduce a slope shifter across different municipalities based on the local pre-tax wage as observed in 2012. The regression equation described in 25 is, thus, augmented in the following manner:

$$\log y_{i,t,q}^{e_m} = \alpha + \beta \log {\tau_R}^{e_m} + \beta_m w_{2012,m} \log {\tau_R}^{e_m} + \gamma_m + \gamma_{LLM,t}^{s_m} + \gamma_q^{s_m} + \varepsilon_R. \tag{26}$$

The aim is to capture only the income ordering of Italian municipalities and avoid potential correlation of local wages with the unobservables.[10] 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 β_m, which governs the heterogeneity in responses.

Lastly, I repeat the empirical estimations described in equations 26 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

[10]The underlying assumption is that in the past 25 years the income ordering of Italian municipalities has not changed significantly.

locations and tenure choices, thus indicating that any mechanism explaining heterogeneity in prices and rents responses should account for the possibility of household reallocation.

5 Regression Analysis

5.1 OLS Regression Analysis

The objective of this paper 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 4 the estimated parameters of the OLS regression described in equation 23. Table 4 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	-0.413^{*}	-0.180	-0.355	1.134^{***}	-0.0583
	(0.275)	(0.220)	(0.391)	(0.264)	(0.135)	(0.164)
Interest Rates		0.0374^{***}		0.0178		0.0196
× Log of Income		(0.0132)		(0.0140)		(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 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 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 4, though, suffer 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.

5.2 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. As such, 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 5 I provide the results of the regression highlighted in equations 25 and 26.

	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^{th} 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 5: 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 5 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 coefficient of table 5 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.

5.3 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 26, 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 6. 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^{*}
$\times$ Log of Income	(0.0209)	(0.00482)
Municipality FE	Yes	Yes
Semester $\times$ LLM FE	Yes	Yes
50^{th} Percentile	-1.087	-0.0709
N	282'242	282'236
R-sq	0.999	0.996

Table 6: 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.

5.4 Robustness Checks

I will run a set of robustness checks regarding the SSIV strategy in order to test its assumptions. 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 25, and in the remaining columns I report the results of the spatially heterogeneous SSIV described by equation 26.

	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
$\times$ 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 $\times$ 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 25, while the remaining columns report the results for the spatially heterogeneous SSIV described in 26. 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.

5.5 Interpretation of the Empirical Estimates

The estimated coefficients of the empirical analysis are not consistent with the CGGVF. The classical interpretation, in fact, implies that the price-to-rent ratios, when including the mortgage interest rate, should be invariant to a mortgage rate shock. Or, in other words a fall (increase) in price-to-rent ratios should fully counteract an increase (fall) in mortgage interest rates. Additionally, if we consider the naive model where the equilibrium tenure-location distribution is not affected by a similar increase in mortgage interest rates across different locations, then the response of price-to-rent ratio in a location should move in different directions.

The CGGVF can be interpreted as a financial no-arbitrage condition, where, in a context of perfect competition, the cost of an asset is equal to the expected stream of returns. The empirical estimations, instead, imply that the local price-to-rent ratios respond to national mortgage interest rate shocks in an asymmetric manner that is not consistent with this no-arbitrage assumption, under which we should not observe any response.[11] In addition, I find that the equilibrium location-tenure distribution of households is also affected by the mortgage rate shock.

The alternative explanation provided by the AGGVF, instead, allows for an asymmetric response

[11] This is true also under the simple dynamic model I show in the appendix.

in local price-to-rent ratios as long as households reallocate across different location-tenure choices with respect to the initial allocation. If the CGGVF captures exclusively the financial interpretation of the price-to-rent ratio, where the ratio is equivalent to the cap-rate of the residential asset, the AGGVF, instead, captures the different local preferences between renting and owning.

It is now possible to rationalize the empirical result in light of the theoretical model. The initial response of the model would be that an increase in mortgage interest rate implies a fall in home-ownership welfare which in turn would increase the share of renters across all locations. Given the lower consumption of housing in cities with higher housing costs and higher wages, home-ownership welfare falls more then in less costly locations. As such, we should observe a movement of agents from richer locations to poorer ones with a higher increase in the share of renters in richer locations.

I will now further validate the model by running a model counterfactual measuring the local price and rent responses to a sizable mortgage rate shock.

6 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.[12] 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 2, 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.

[12] In the additional results provided in the appendix I also observe a larger price-to-rent ratio responses in richer locations.

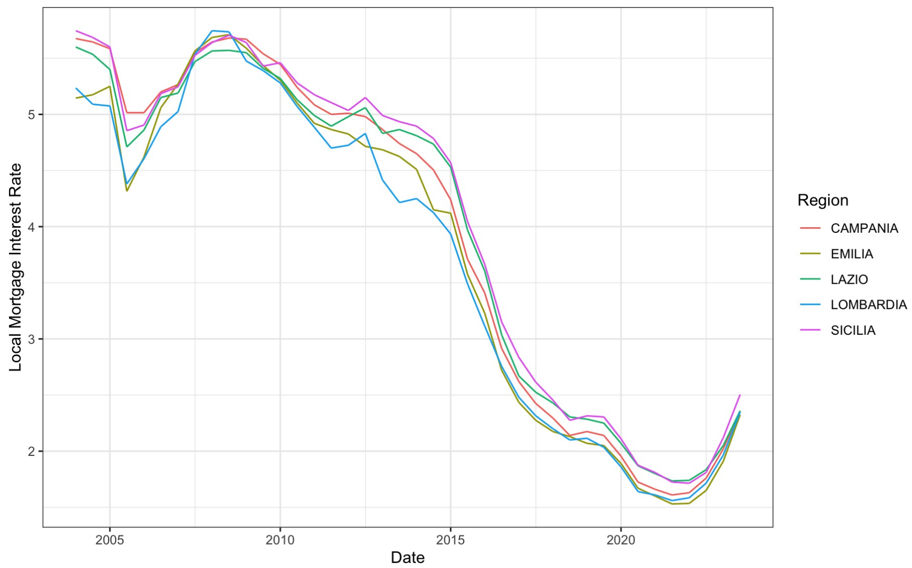

Figure 2: The graph reports the local mortgage rates between 2004 and 2023 in Italy across five different regions covering most of the Italian population: Lombardia, Emilia-Romagna, Lazio, Sicilia, and Campania.

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

6.1 Targeted Parameters

Before estimating the parameters of interest I rearrange the model, in order to better estimate μ_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 $i =$ 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 3.

Figure 3: 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: ϕ_1 is the parameter for the generic consumption good and β 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 σ_t and σ_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 ρ_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.

6.2 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 ϕ_1 and ϕ_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 β, σ_t, and σ_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

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

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

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

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.[13]

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.[14] Having now recovered the supply after the perturbation it is possible to recover ρ_i and $\bar{H}_i$. Defining H_i' and p_i' as the outcomes of the perturbated model, I can exploit the 14 to isolate ρ_i. To do so I consider

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

[13] As stated before I set Padova to be the reference LLM, setting $A_{Padova=1}$.

[14] The distribution of the results is reported in the appendix.

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 ρ_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

$$\sum_x \left(\sum_i |\varepsilon_i^x| - \sum_i |\epsilon_i^x| \right) \tag{27}$$

Where I indicate with ϵ_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 ε_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 14. I then compute local prices and rents with the local 2023 interest rates.

Summarizing the algorithm:

- Recover ϕ_1 and ϕ_2 from the observed shares of expenditures on housing paid by renters.
- Set the outer shell by guessing β, σ_l and σ_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 τ_i by 1%.
  - Retrieve the supply elasticities by matching the local price elasticites.
  - Retrieve ρ_i and $\bar{H}_i$ through the computed supply elasticities.
- Iterate the inner shell in order to select β, σ_l and σ_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.

6.3 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 9.

Parameter	Estimation
β	0.0074
σ_t	4.011
σ_l	24.973

Table 9: In the table I report the estimated global variables. β is associated to the home-ownership value for households. σ_t and σ_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.[15] Additionally, prices capture the home-ownership cost associated with a real estate property. I report in table 10 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 10: 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 11.

[15] The main objective of the present paper is not to solve the dimensionality issue affecting dynamic spatial models 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 11: 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 12.

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

Table 12: 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.[16]

6.4 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.[17] 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

[16] The estimated correlation between ρ_i and the local wage is positive in the present research.

[17] 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.

would be to provide a dynamic model, which would allow me to capture the dynamic interactions 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.[18] 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.

7 Conclusion

Residential real estate possesses a dual nature, functioning simultaneously as a consumption good and as an investment asset. This intrinsic duality gives rise to two complementary interpretations of the price-to-rent ratio: a financial interpretation and a relative-preference interpretation. The financial interpretation treats housing as an asset yielding an expected stream of returns equivalent to the expected stream of rents. Under the assumption of a competitive property market, the no-arbitrage condition implies that prices should equal the expected discounted value of future rents. The relative-preference interpretation, by contrast, assumes that renting and home-ownership represent distinct forms of housing consumption and that the populations of renters and home-owners differ, at least in part, in their preferences or constraints. It follows that the spatial variation in housing prices and rents arises from different local equilibria of demand and supply in both the ownership and rental markets.

The financial interpretation, which underlies most recent theoretical models, yields a clear prediction regarding the response of price-to-rent ratios to changes in local mortgage interest rates. According to the Classical Gordon Growth Valuation Formula, a no-arbitrage condition between real estate prices and their expected returns, a mortgage interest rate increase (decrease) causes a price-to-rent ratios decrease (increase), resulting in no net aggregate effect. In contrast, I develop a static spatial model in which households jointly determine their location and tenure status, and where home-owners enjoy an additional utility from ownership beyond the consumption of housing services. The resulting formulation of the price-to-rent ratio embeds both the financial interpre-

[18] I provide in the appendix a simple model for both.

tation and an additional component linked to the local share of home-owners, thus capturing the relative-preference dimension. Under these assumptions, the price-to-rent ratio serves as a sufficient statistic for the relative local welfare of renters vis-à-vis homeowners.

To empirically test the price-to-rent ratio response predicted by the Classical Gordon Growth Valuation Formula, I exploit a granular dataset on the Italian property and rental markets spanning the past two decades. This dataset allows for accurate measurement of prices and rents for comparable properties, thereby mitigating quality-related biases that typically hinder cross-market comparisons. Furthermore, I employ a novel shift-share instrumental variable strategy, that leverages variation in mortgage uptake rates across demographic groups and their uneven spatial distribution. Specifically, I expect that a supply-driven mortgage rate shock, instrumented through a composite Eurozone mortgage interest rate, has an heterogeneous effect across locations depending on their demographic composition. Areas with older populations, where housing transactions are less frequent and mortgage financing less prevalent, are expected to respond differently than areas with younger, more mortgage-dependent households.

The empirical evidence presented in this paper leads to a rejection of the Classical Gordon Growth Valuation Formula. Specifically, I find that the observed responses of local price-to-rent ratios is insufficient to fully offset changes in mortgage interest rates, an outcome that aligns instead with the predictions of the model developed in this study. Moreover, both local prices and rents exhibit heterogeneous responses to mortgage rate shocks across locations, while being positively correlated within locations. This pattern is consistent with a spatial reallocation of households triggered by shifts in mortgage financing conditions.

To further validate the model, I conduct a counterfactual simulation replicating the sharp increase in mortgage interest rates observed in Italy between 2021 and 2023. The counterfactual results are consistent with the empirical evidence, reproducing the asymmetric spatial responses in housing prices, rents, price-to-rent ratios, and tenure choices. In addition, the simulation suggests that a nationwide mortgage rate hike would have heterogeneous welfare effects across space, leading to a reduction in both spatial disparities and the welfare gap between homeowners and renters.

Overall, this paper advances the literature on residential real estate markets by introducing a novel analytical framework that links housing market dynamics to the spatial distribution of welfare among homeowners and renters. Future research may build on this foundation to explore more comprehensively the welfare and tenure-redistribution implications of housing policy interventions.

References

Ahlfeldt, G. M., Heblich, S., & Seidel, T. (2023). Micro-geographic property price and rent indices. *Regional Science and Urban Economics*, *98*, 103836. doi:10.1016/j.regsciurbeco.2022.103836

Ahlfeldt, G. M., Redding, S. J., Sturm, D. M., & Wolf, N. (2015). The economics of density: Evidence from the berlin wall. *Econometrica*, *83*(6), 2127–2189. doi:10.3982/ECTA10876

Akgündüz, Y. E., Dursun-de Neef, H. Ö., Hacihasanoğlu, Y. S., & Yılmaz, F. (2023). Cost of credit, mortgage demand and house prices. *Journal of Banking & Finance*, *154*, 106953. doi:10.1016/j.jbankfin.2023.106953

Almuzara, M., & Sancibrián, V. (2025). Micro responses to macro shocks. *Working Paper*. Series: Staff Reports (Federal Reserve Bank of New York). doi:10.59576/sr.1090

Amaral, F., Dohmen, M., Kohl, S., & Schularick, M. (2023). Interest rates and the spatial polarization of housing markets. *American Economic Review: Insights*, *Forthcoming*.

Autor, D. H., Dorn, D., & Hanson, G. H. (2013). The china syndrome: Local labor market effects of import competition in the united states. *American Economic Review*, *103*(6), 2121–2168. doi:10.1257/aer.103.6.2121

Begley, J., Loewenstein, L., & Willen, P. S. (2019). The price-rent ratio during the boom and bust: Measurement and implications. *Working Paper*.

Benhabib, J., & Bisin, A. (2018). Skewed wealth distributions: Theory and empirics. *Journal of Economic Literature*, *56*(4), 1261–1291. doi:10.1257/jel.20161390

Borusyak, K., Hull, P., & Jaravel, X. (2022). Quasi-experimental shift-share research designs. *Review of Economic Studies*, *89*(1), 181–213. doi:10.1093/restud/rdab030

Bracke, P. (2015). House prices and rents: Microevidence from a matched data set in central london: House prices and rents. *Real Estate Economics*, *43*(2), 403–431. doi:10.1111/1540-6229.12062

Campbell, S. D., Davis, M. A., Gallin, J., & Martin, R. F. (2009). What moves housing markets: A variance decomposition of the rent–price ratio. *Journal of Urban Economics*, *66*(2), 90–102. doi:10.1016/j.jue.2009.06.002

Dias, D. A., & Duarte, J. B. (2019). Monetary policy, housing rents, and inflation dynamics. *Journal of Applied Econometrics*, *34*(5), 673–687. doi:10.1002/jae.2679

Favilukis, J., Ludvigson, S. C., & Van Nieuwerburgh, S. (2025). The macroeconomic effects of housing wealth, housing finance, and limited risk sharing in general equilibrium. *Journal of Political Economy*, *125*(1), 140–223.

Gete, P., & Reher, M. (2018). Mortgage supply and housing rents. *Review of Financial Studies*, *31*(12), 4884–4911. doi:10.1093/rfs/hhx145

Ghiraldo, E., & Marignoli, L. (2023). Acquirenti e venditori delle compravendite immobiliari. *Quaderni dell'Osservatorio*, *12*, 7–32.

Glaeser, E. L., Gyourko, J., Morales, E., & Nathanson, C. G. (2014). Housing dynamics: An urban approach. *Journal of Urban Economics*, *81*, 45–56. doi:10.1016/j.jue.2014.02.003

Gli immobili in italia. (2023). Agenzia delle Entrate. Roma.

Gordon, M. J., & Shapiro, E. (1956). Capital equipment analysis: The required rate of profit. *Management Science*, *3*(1), 102–110. doi:10.1287/mnsc.3.1.102

Greaney, B., Parkhomenko, A., & Van Nieuwerburgh, S. (2025). Dynamic urban economics. *Working Paper*.

Hahn, J., Kuersteiner, G., Santos, A., & Willigrod, W. (2025). Overidentification in shift-share designs. *Working Paper*.

Henderson, J. V., & Ioannides, Y. M. (1983). A model of housing tenure choice. *American Economic Review*, *73*(1), 98–113.

Howard, G., & Liebersohn, J. (2023). Regional divergence and house prices. *Review of Economic Dynamics*, *49*, 312–350. doi:10.1016/j.red.2022.10.002

Kleinman, B., Liu, E., & Redding, S. J. (2023). Dynamic spatial general equilibrium. *Econometrica*, *91*(2), 385–424. doi:10.3982/ECTA20273

Krainer, J., & LeRoy, S. F. (2002). Equilibrium valuation of illiquid assets. *Economic Theory*, *19*(2), 223–242. doi:10.1007/PL00004214

Moktan, S. (2025). An empirical equilibrium model of the markets for rental and owner-occupied housing. *Working Paper*.

Piazzesi, M., & Schneider, M. (2016). Housing and macroeconomics. In *Handbook of macroeconomics* (Vol. 2, pp. 1547–1640). doi:10.1016/bs.hesmac.2016.06.003

Poterba, J. M. (1984). Tax subsidies to owner-occupied housing: An asset-market approach. *Quarterly Journal of Economics*, *99*(4), 729. doi:10.2307/1883123

Redding, S. J., & Rossi-Hansberg, E. (2017). Quantitative spatial economics. *Annual Review of Economics*, *9*, 21–58.

Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy*, *90*(6), 1257–1278. doi:10.1086/261120

Rodríguez-Clare, A., Ulate, M., & Vásquez, J. P. (2022). Trade with nominal rigidities: Understanding the unemployment and welfare effects of the china shock. *Working Paper*.

Sommer, K., Sullivan, P., & Verbrugge, R. (2013). The equilibrium effect of fundamentals on house prices and rents. *Journal of Monetary Economics*, *60*(7), 854–870. doi:10.1016/j.jmoneco.2013.04.017

Van Nieuwerburgh, S., & Weill, P.-O. (2010). Why has house price dispersion gone up? *Review of Economic Studies*, *77*(4), 1567–1606.

Vanhapelto, T. (2022). House prices and rents in a dynamic spatial equilibrium. *Working Paper*.

A Additional Figures

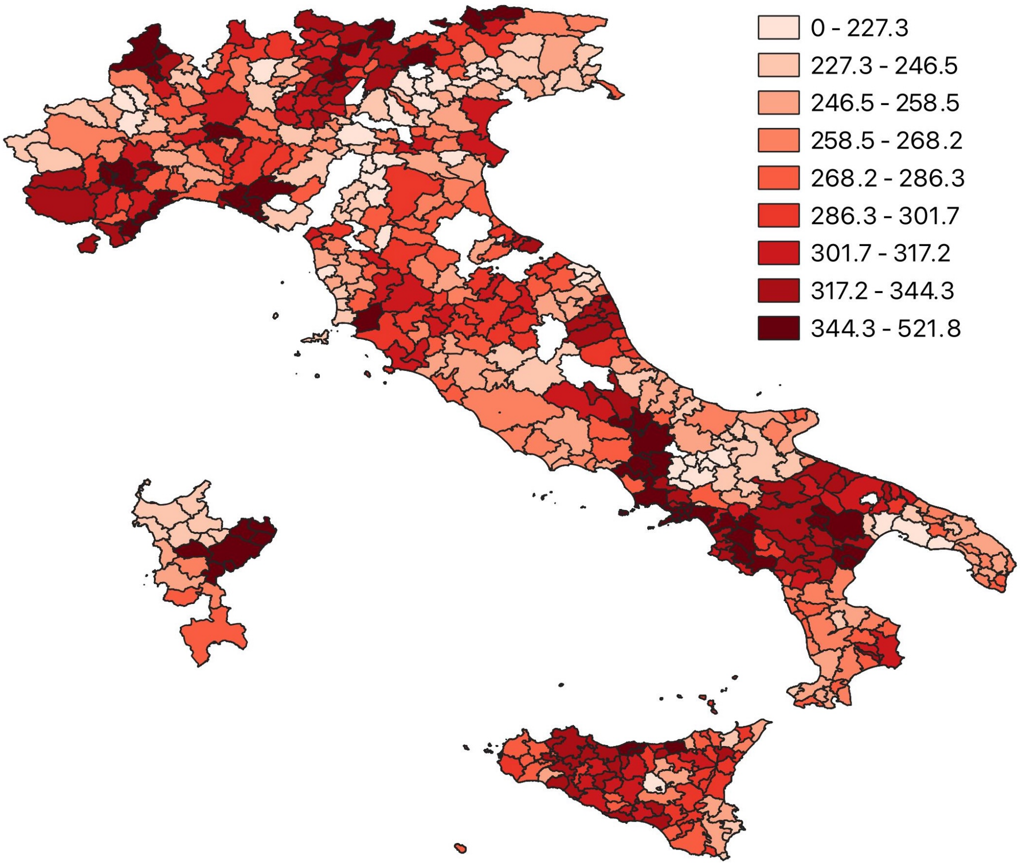

Figure 4: Weighted average of local price-to-rent ratios across different local labor markets in Italy for housing of similar quality in 2019

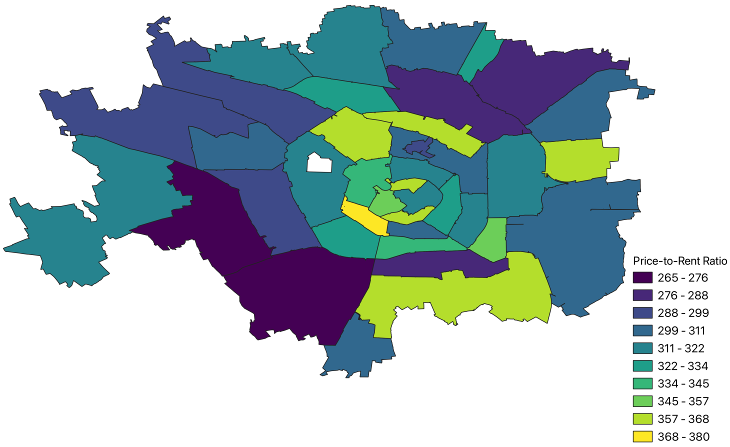

Figure 5: Local price-to-rent ratios across different neighborhoods in Milan for housing of similar quality in 2019

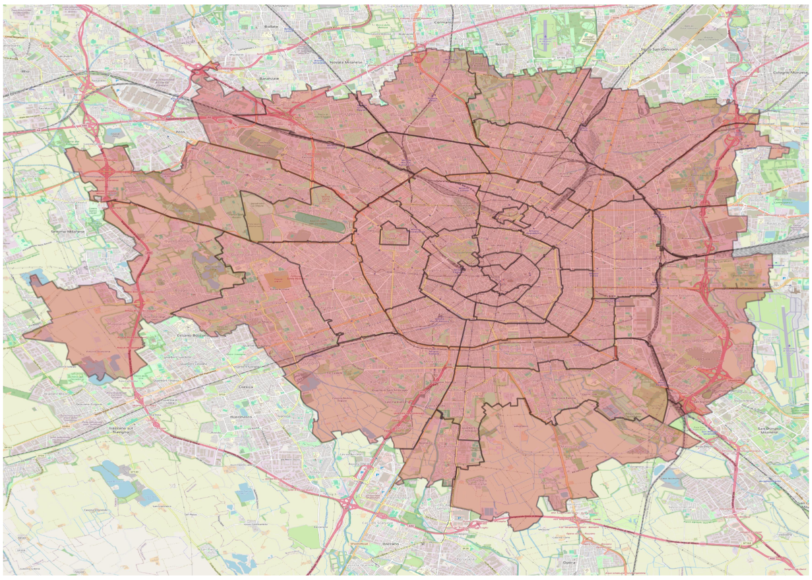

Figure 6: I plot the OMI zones for the municipality of Milan over the city map for the year 2019.

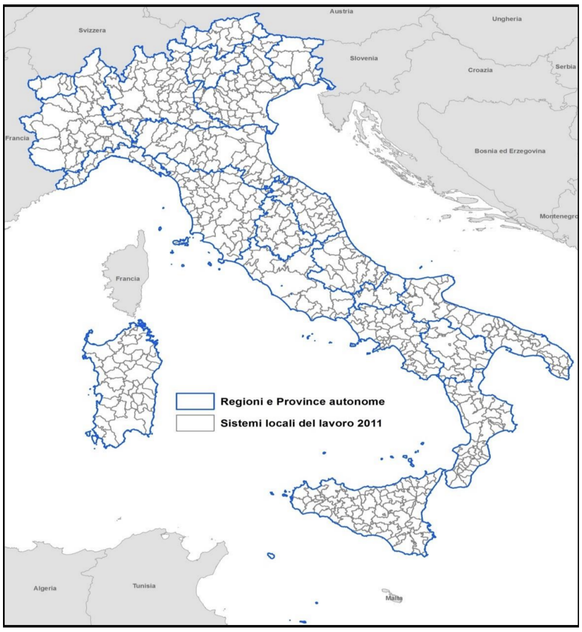

Figure 7: Istat divided the Italian territory in 612 local labor market based on local commuting patterns. The map reports the local labor markets overlayed on the administrative regional borders.

B Model Extensions

B.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:

$$\frac{(1+\tau)p_i}{r_i} = 1 + \frac{\beta}{(1-\phi_1)(1+\beta)} \frac{\sum_{\iota\in\{H,L\}} w_i^\iota \,\mathrm{Pop}_{i,\mathrm{buyer}}^\iota}{\sum_{\iota\in\{H,L\}} \left(w_i^\iota \,\mathrm{Pop}_{i,\mathrm{renter}}^\iota + \frac{w_i^\iota}{1+\beta}\mathrm{Pop}_{i,\mathrm{buyer}}^\iota\right)} \tag{28}$$

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.2 Dynamic Formulation of the CGGVF

I will now consider the standard formulation for the CGGVF, in the contest 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

$$(1 + \tau_i^0)\, p_i^0 = \sum_{t=0}^{+\infty} \tilde{\beta}^t\, r_i^t \tag{29}$$

Where I measure with $\tilde{\beta}$ the discount rate which is equal to the safe asset interest rate $(1+Rate)$. Following Amaral, Dohmen, Kohl, and Schularick, 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

$$(1 + \tau_i^0)\, p_i^0 = r_i^0\, \frac{1 + Rate}{Rate - g_i} \tag{30}$$

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

$$\frac{(1 + \tau_i^0)\, p_i^0}{r_i^0} = \frac{1 + Rate}{Rate - g_i} \tag{31}$$

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 31.

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 Robustness Checks and Additional Estimations

In this section I report a set of robustness checks of the empirical analysis and a set of additional results to further test the main hypothesis of the paper.

I report in table 15 the first stage of the regression between the Eurozone composite mortgage interest rate and the regional Italian ones.

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

Table 13: 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 × 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 5 with a weight based on the local municipal population divided by the number of municipal OMI zones. I report the results in table 14.

	Prices		Rents		Price-to-Rent	
	(1)	(2)	(3)	(4)	(5)	(6)
Interest Rates	-0.372^{**}	-0.950^{**}	-0.543^{***}	-1.133^{***}	0.929^{***}	0.941^{***}
	(0.168)	(0.341)	(0.173)	(0.236)	(0.144)	(0.224)
Interest Rates		0.0816^{**}		0.0832^{**}		-0.00169
$\times$ Log of Income		(0.0304)		(0.0330)		(0.0196)
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	0.892	0.892	0.843	0.843	0.957	0.957

Table 14: 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 14 are consistent with those in table 5, 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 the specification of table 5. 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.[19] I report the results in table 15.

[19] 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	−0.920	−0.302	−1.335	0.748***	1.181**
	(0.264)	(0.554)	(0.246)	(0.891)	(0.0764)	(0.457)
Interest Rates		0.0611*		0.105		−0.0441
× Log of Income		(0.0345)		(0.0709)		(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 15: 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 5. 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 5, by restricting the samples based on two different criteria. In the first set of regressions, described in table 16 and 17, I restrict the sample based on local municipal wage. In table 16 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
$\times$ 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 $\times$ 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 16: 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 17, instead, I restrict the sample to the top decile municipalities with respect to local 2012 incomes.

	Prices		Rents		Price-to-Rent	
	(1)	(2)	(3)	(4)	(5)	(6)
Interest Rates	-0.287^{*}	-0.259	-0.405^{*}	-0.609	0.871^{***}	1.105^{***}
	(0.142)	(0.543)	(0.202)	(0.584)	(0.147)	(0.367)
Interest Rates		-0.00351		0.0247		-0.0282
× Log of Income		(0.0582)		(0.0593)		(0.0350)
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	343'737	1'027'700	1'027'700	1'027'700	1'027'700	1'027'700
R-sq	0.846		0.795		0.961	

Table 17: 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 16 and 17, it is consistent with the spatial asymmetry of the main estimations. I observe a lower response in prices and rents with respect to mortgage interest rate when I restrict the estimation to the municipalities with higher local income, with respect to the estimations restricted to the municipalities with lower local income. 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.

Lastly, I repeat the SSIV estimation as reported in equation 25 by restricting the sample to each LLM. I map the results of price and rent elasticites with respect to mortgage interest rates in figure 8

To test whether the results are consistent with the main results in table 5, I compute the correlation between the price and the rent elasticities. I should expect that the local price and rent elasticities are positively correlated. I plot in figure 9 the estimated LLM elasticities, with the price elasticities on the x-axis and the rent elasticities on the y-axis.

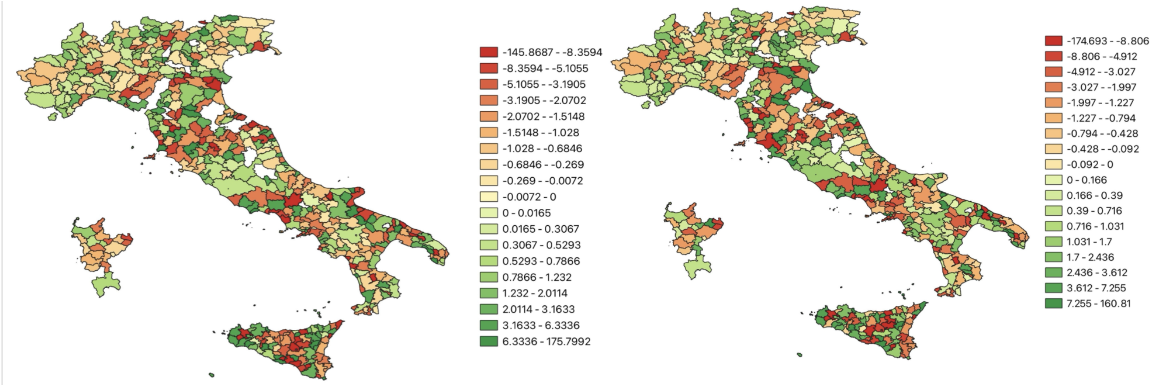

Figure 8: On the left I plot the estimated local price elasticities with respect to the local mortgage interest rates on the map of Italy. On the right I plot the estimated local rent elasticities with respect to the local mortgage interest rates. If the estimated elasticity is positive I plot the results 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.

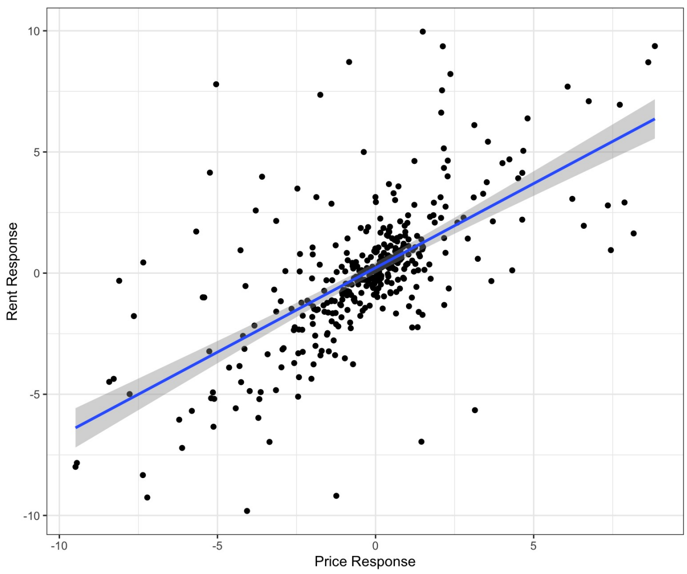

Figure 9: On the x-axis I plot the elasticities of prices with respect to local mortgage rates, on the y-axis I plot the elasticities of rents with respect to mortgage rates. Each dot represents an Italian local labor market.

As expected the results are consistent with the main results as there is a positive correlation between local price and rent elasticities. This result is not consistent with an environment where households do not respond across locations and tenure choices to a mortgage rate shock. I now map the estimated price-to-rent ratio elasticities with respect to the local mortgage interest rates in figure 10.

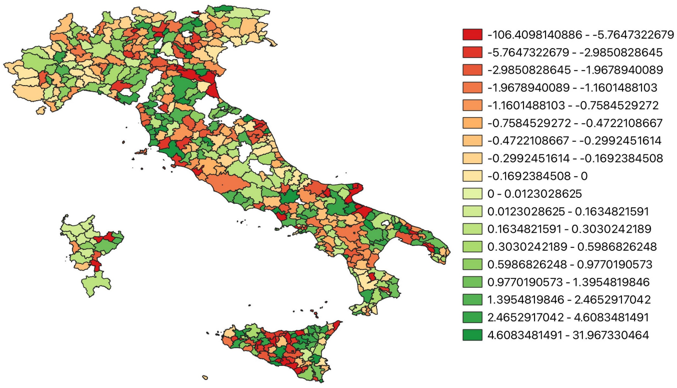

Figure 10: On the x-axis I plot the elasticities of prices with respect to local mortgage rates, on the y-axis I plot the elasticities of rents with respect to mortgage rates. Each dot represents an Italian local labor market.

In this case I observe that price-to-rent ratio responses are heterogeneous across locations and, consistent with the estimations reported in table 17, I observe that there are locations where the local elasticities of price-to-rent ratio with respect to mortgage interest rates are positive. This result is not consistent with the CGGVF and can be explained only with household that reallocate themselves across locations and tenure choices. To check whether these results are consistent with the previous estimations I regress the elasticities of prices, rents, and price-to-rent ratios with respect to the local municipal wage. I report the estimated coefficients in table 18.

	Price Elasticities	Rents Elasticities	Price-to-Rent Elasticities
Log of Income	-0.286	-0.752^{*}	0.435
	(0.374)	(0.391)	(0.576)
Region FE	Yes	Yes	Yes
N	7'154	7'154	7'154
R-sq	0.010	0.020	0.012

Table 18: Income is measured as in 2014. 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

Even though the estimated coefficients are not significant at the 0.05 level, I observe that the direction of the correlation is consistent with that of the estimated coefficients of the main result as reported in table 5 and with the results of the counterfactual estimation.