Property Taxation and Real Estate Price Dispersion*

Alberto Nasi†

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Abstract

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

JEL Codes: G12, H24, R21, R31, R38

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

1 Introduction

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

The objective of the paper is twofold. On the empirical side the aim is to explore the claim set out by the seminal paper by Hamilton (1976) and reaffirmed by Zodrow (2014) that one of the consequences of the property tax is to reduce the price dispersion due to unobservables. I will follow previous research adopting reduced form methods, but I will focus on the specific design of the Italian real estate tax. Spatially, the tax provides a fiscal incidence variation across local jurisdictions. While on the dynamic side, the Italian real estate taxation policy went through a series of design changes which changed the pool of properties affected between 2006 and 2013. The two provide a combination of temporal and spatial variation across the Italian real estate properties with two important consequences. On the one hand it will enable me to avoid the endogenous political choice of the local tax rate. Even if a municipal administration adjusts the tax rate to respond to the national policy, they cannot impose different tax rates in different locations within the city. On the other hand, the two together provide an exogenous policy variation across the country which I will be able to exploit to identify the specific effect of the Italian property tax and its partial removal. An additional novelty with respect to the previous literature is the data I use. The Italian fiscal agency provides aggregate data on the minimum and maximum prices and rents for several types of real estate properties between 2002 and 2020 biannually in small homogeneous areas. As such I am able to abstract from local characteristics influencing the price of a property, while controlling for the general quality of the construction and the relative location with respect to the city. A further characteristic is that the data includes all the information the fiscal agency is able to observe, thus leaving the remaining price variations to unobservable characteristics.

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

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

2 Literature Review

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

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

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

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

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

Han (2012) and Carrillo (2012).

On the empirical side, most research tries to answer one of the two questions: what is the degree of capitalization of the property tax in the housing prices and how do different policies and frictions affect property prices. Most studies adopt a reduced form approach in order to capture the effect of the property tax on capitalization. There are two issues that different identification strategies attempt to work around. On the one hand, there is the issue of spurious correlation between property prices, property taxes and public good provision. The empirical issue has been around since the study of Oates (1969) as surveyed by Palmon and Smith (1998), both of which argue that the data is consistent with a full capitalization of the property tax through a Hamilton-Tiebout mechanism. Oliviero and Scognamiglio (2019) focuses on the same institutional setting of the the present paper from a political economy angle. They find that Italian municipalities have a higher probability to react to the possibility of adjusting the property tax rate based on the proximity of a local election. Municipalities that respond in such a manner are more inefficient and have lower social trust. Additionally, Italian properties react to the variation in property taxation, an evidence that there is some capitalization in the Italian setting, despite the complexity of the computation of the tax. The identification strategy of the current study will avoid this endogeneity by focusing on within-city variation in taxes. In the American setting, both Bradbury, Mayer, and Case (2001) and Lang and Jian (2004) exploit the introduction of a constraint on spending in Massachusetts to study the capitalization of property taxes and public goods. While the former finds that constrained communities were able to increase their public spending due to an increase in property values and, thus, in local revenues and that public spending did not affect property prices, contradicting the Hamilton-Tiebout mechanism, the latter study finds that the constraint reduced property values and communities that were able to increase public spending more in the subsequent years enjoyed higher property prices. Lang and Jian (2004) argue that the issue with Bradbury et al. (2001) is that the latter considered public spending as exogenous and not endogenously set by the lawmakers. Giertz, Ramezani, and Beron (2021) study the capitalization of the property tax in Dallas county exploiting a variation in tax rates across jurisdiction through a DiD approach with administrative data. They cannot reject the hypothesis of full capitalization and find that urban taxes have higher degree of capitalization. The result is consistent with the argument, set forth by Lutz (2015) and Oates and Fischel (2016), that the benefit view is more consistent with urban environments, where there is less availability of land, while the capital-tax view applies more to suburban environments.

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

Given that property taxes are often the main direct fiscal revenue source for local administration, there is a wide literature in public finance that intersects with the topic at study in this paper. Lutz (2008) and Lutz, Molloy, and Shan (2011) find that local municipalities respond to variations of prices on the housing market when setting the property tax rate. The lag is explained by institutional features of the property tax and by delays in assessments. An additional set of papers focus on different types of property taxation, focusing on transaction and acquisition-value ones. Both O'Sullivan, Sexton, and Sheffrin (1995) and Best and Kleven (2018) find that the transaction value tax has strong distortionary effects and Kopczuk and Munroe (2015) finds further evidence that when notches in the fiscal framework are introduced there is an additional risk of the market unraveling above these thresholds. Regarding acquisition-value taxes both O'Sullivan et al. (1995) and Wasi and White (2005) find that mobility is reduced as home-owners tend to stay in their properties longer than in other jurisdictions in order to reap the increasingly favourable market value on taxation ratio.

Shifting the focus of property taxes from property prices to rents, the question is whether renters shift part of the cost of a property tax to tenants. Both Hyman and Pasour (1973) and Löffler and Siegloch (2021) find that differences in property taxation are shifted forward to tenants. The latter study, in particular, points out that an increase in property taxes leads to an initial partial pass-through, which increases to a full pass-through in the following years. Dusansky, Ingber, and Karatjas (1981) tries to combine in a single econometric model both renters and homeowners and finds a partial capitalization of a property tax, partial pass-through of the tax to renters, and association of higher rental units with lower property prices. Additionally, they argue that actual rental values are a bad proxy for housing prices, suggesting that the two have to be considered as separate markets with different frictions.[1]

The last strand of literature related to the current study is the one related to wealth taxation. Real estate is one of the few widely taxed assets in Western countries and thus we can try to infer some potential effects of taxation on capital supply. Following the limitations of Jakobsen, Jakobsen, Kleven, and Zucman (2020), tying these strands of literature can provide several benefits. First, it is possible to study a widely distributed asset, such as real estate, and the effect of a property tax on the forward-looking behaviour of those aspiring to own a property.[2] Second, given the institutional setting of the present study it is possible to study shifts between different allocation of capital, thus capturing more general equilibrium effects of property taxation. On the one hand, we have house ownership versus renting, capturing the saving nature of real estate. On the other hand, we can study the supply of capital between residential ownership, ownership with the intention of renting, and urban real estate as an input for production.[3] It is also important to point out that, while real estate capital is still exposed to capital mobility, in particular high-value business projects, the widespread ownership of housing wealth relative to other types of assets reduces the risk of international movement among the wealthy and the risk of sampling a reduced pool of super-wealthy. Furthermore, excluding a set of policy papers such as OECD (2018) and McDonnell (2013) both of which do not focus on the specific issue at hand, it is the first paper to my knowledge tying the construction of a wealth tax policy and the issue of value assessment.

3 Institutional Setting: The Italian Property Taxes

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

The Italian property taxation is designed as an assessed value framework and the revenue is mostly earmarked for municipal jurisdiction.[4] Given that a real estate property is not continuously

[1] Instead of assuming property prices as the present value of the stream of rents.

[2] Such as the rent versus buying question.

[3] I.e. offices and shops

[4] With the exclusion of a specific set of special properties such as industrial complexes, which tax revenue is

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

In order to compute the amount owed to the state for residential property a set of information regarding the observables is needed: the location of the property and the corresponding *tariffa d'estimo*, the category and class, the number of *vani*[5], and the municipal tax rate. I will explain each one of the elements and provide an example.

- **Location**: The location is one of the two main observables evaluated by the state. In 1950 the Italian state was divided in different relatively homogeneous areas in order to create the new postwar cadastre. These areas coincide most of the times with the area of a specific municipal jurisdiction, but larger centres are divided in more than one homogeneous area, which I will refer to as *Zone Censuarie* (ZC).[6] For each category and class of residential property, the state provides a *tariffa d'estimo* (estimated price) for each *vano*.

- **Category and Class**: Every property in Italy has to be registered with the state at the cadastre which assigns a category, based on the usage of the property and its quality, and a class, which refers to local quality within a class. in particular the category registers the usage (i.e. *A* for residential building, *B* for buildings of public interest such as religious buildings and public libraries) and the general quality (i.e. *A/2* indicates the civilian residences and *A/9* indicates castles and historical palaces). The class range varies between *zone censuarie* and tries to capture the relative quality of a property relative to others of the same category and location.

- **Number of Vani**: the size of a residential property is not assessed specifically by size but in terms of the number of useful rooms (*vani*) it has. In particular, living rooms, bedrooms, and

earmarked directly to the central government.

[5]Singular *vano*, plural *vani*

[6]Milan, for example, is divided into three areas as I show in the appendix.

furnished kitchens are considered *vani*, but not restrooms. There are further specific rules but they apply to specifically large rooms which are rarely the case and thus I will ignore them for the sake of simplicity.

- **Municipal Tax Rate**: Given that property taxation is the main source of revenue of the municipal authorities, the local councils are allowed to set the tax rate within a nationally specified boundary.

It is important to specify that the Italian cadastre assessment of the properties are rarely fully reflective of the true market price of a property. There are two reasons for this: first, local amenities change. The *tariffe d'estimo* were set between 1991 and 1994 and most cities have evolved in the mean time. Additionally the *zone censuarie* were set in the 1950 and are not able to capture more local changes in amenities.[7] Second, people rarely re-register their houses after a renovations and there is no required law for re-assessment by the cadastre at any specified point in time. Thus the category and class of a property reflect out of date assessments. While this is not usually the case for important renovations, such that the general class changes (i.e. from category A, residential properties, to D, mainly properties with industrial destination), it is much more selient for smaller changes (i.e. consider renovations between properties of categories A/2 to A/5, which encompasses macro qualities such as civilian properties to 'ultra-demotic' properties). An extreme assumption is that the tax is so out of date with respect to residential houses, that within *zona censuaria* it is analogous to a randomized head tax.

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

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

Even though the tax was set close to the low boundary of the allowed tax by a municipal administration that was very close to Berlusconi and thus politically adverse to the property tax,

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

it is a sizable amount. To give an idea of the size of the tax let us consider the yearly rent for this property if it was rented for the full year. The average rent per square meter for a property of average quality in the neighborhood of Dateo in 2007 was 11.75€. Considering that the property has approximately 100 square meters, the yearly rent was 14.100€. This translates to a 4.5% property tax for this specific assessment, which was particularly generous to the owner.

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

The experience of the third Berlusconi government ended in 2006 following the natural course of the parliamentary calendar of the Italian Republic and two political poles emerged participating in the subsequent elections. Silvio Berlusconi led the centre-right, while Romano Prodi led the centre-left. During the 2006 elections Berlusconi publicly declared during a televised debate that, if elected, he would have abolished the property tax on the main residences.[8] While the centre-right coalition lost the 2006 elections, the following centre-left government led by Prodi lasted less than two years and the country went back to elections in 2008. The result was a large majority for the centre-right coalition and the birth of the fourth Berlusconi government. In line with the previous promises the new government abolished the property tax on the main residences.

Later, during the crisis of the early 2010's the tax was rebranded as the Imposta Municipale Unica (IMU) and reintroduced on the main residences during the passage between the fourth Berlusconi government and the technocratic Monti government. Lastly the tax was abolished again on the main residences by the coalition government of Letta in 2014. As I will argue later these institutional changes will provide a new source of variation for this study. For completeness I will report that in 2020 the second Conte government created a 'New IMU' which incorporated part of other local taxes, in particular the one named TASI, which shifted an additional fiscal burden from the renters to the landlords. Table 1 summarizes the institutional changes of the tax.

[8] In Italian *prime case*

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

Table 1: Italian property tax timetable.

4 Data

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

As described in the previous section, in order to compute the assessed value of a property I need the category, the *tariffe d'estimo* and the location of a property. With these it is possible to compute the estimated price per *vano* and thus the tax owed to the state. The tables with the *tariffe d'estimo* are publicly available on the site of the *Gazzetta Ufficiale*, the official Italian legislative journal. I collect for each *Zona Censuaria* the median class for a residential property of class A/3 (demotic residential properties). I also check that the ratio between the *tariffe d'estimo* for properties of class A/2 (residential properties) and A/3, and it is roughly constant, thus validating the choice for the incidence of taxation proxy.

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

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

Table 2: Mapped cities.

Regarding the market price of housing I rely on the Osservatorio del Mercato Immobiliare (OMI), a centre study of the Agenzia delle Entrate, the Italian tax authority which oversees the cadastre. The think tank follows the movements of the Italian real estate market through the actual deeds.[9] They divide the whole country in several homogeneous socio-economic areas and then they provide a range of possible values per square meters both for renting and buying for different types of real estate (i.e. residential buildings, offices, industrial buildings, etc.) and different levels of quality (low, normal, and high).[10] The different areas, which I will refer to as OMI areas, are further categorized with respect to their relative position in the local jurisdiction. In particular five areas are defined: B, C, D, E, and R, where B indicates central areas, C semi-central ones, D peripheral, E suburban, and R extra-urban. Data is available between the second semester of 2002 and the second semester of 2021. It is important to stress that prices for residential properties are partially reported since second semester of 2003 and fully since the first semester of 2004. Lastly, it is important to stress that the OMI revises the OMI areas approximately every 10 years. The only revision up to now has happened in 2014, which has updated the different areas, but it is not possible to easily connect an

[9] Thus, post eventual negotiations.

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

area post update to the one pre update.

Summarizing, if I refer to the Roman C40 area, set in 2021, I refer to the area that covers roughly the Rione Prati in Rome, which is categorized as semi-central. Unless specified I will always restrict my analysis to civilian residences. Table 3 summarizes the dataset.

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

Table 3: Summary of the OMI dataset (2003).

5 Reduced Form Analysis

5.1 Identification Strategy

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

The main regression will thus be as following

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

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

- **OMI areas**: a fixed effect which should capture local amenities and the distance from the central business district. As OMI areas are computed to be socio-economically homogeneous, they should also capture, at least partially, the income sorting of individuals within a city.
- **Semester**: A time fixed effect.
- **City-semester**: A fixed effect capturing local municipal trends. Variations in the local tax rate and in the provision of local public goods will be captured by this set of dummy variables. Providing the control for smaller geographical areas would have been unfeasible as the number of dummy variables would have greatly risen. I regard the city-semester specification an acceptable, albeit not perfect, level in order to capture the effects of interest.
- **Quality**: When data is available I can control for the quality of the property. Quality captures maintenance levels and the quality of the internal finishes. For commercial properties such as shops, it measures also the quality of the position of the property itself.

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

$$\text{Price}_{t,o,l,q} = \alpha + \sum_{t=1}^{T} \mathbb{1}(\text{Tax on main residences}) * \beta_{t,o} * \text{Tariffa d'Estimo}_{o,l} + \gamma_o + \gamma_t + \gamma_{c,t} + \gamma_q. \quad (2)$$

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

5.2 Main Results

First I will report the results for the regression over all nine cities with respect to equation 1. Standard errors are clustered at the OMI area level. In table 4 I display the main results of the base regressions. Column (1) indicates the regression for the lower bound of the residential per square meter prices, while column (2) reports the same results for the higher bound.

Prices	(1)	(2)
Tariffa d'estimo	-1.043^{***}	-1.405^{***}
	(0.250)	(0.270)
N	22542	22542
R^2	0.975	0.968
Bound	Lower	Upper

Table 4: Table of Results: National.

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

While we cannot reject the hypothesis that the two coefficients are the same, the results are consistent with the Hamilton theoretical findings that argue that, with a property tax in a mixed community, higher priced properties are traded with a discount, as they overpay in taxes for the public good as long as the number of *vani* is constant. It is also possible that the regression is capturing differences in sizes for properties at different points in the distribution of prices. In particular, if the properties are traded with a premium based on size where larger properties are traded at a higher per square meter price, then the regression might be capturing the fact that the properties closer to higher bound of the distribution of sizes tend to be larger and, thus, pay more taxes. What I would be capturing is the effect of a larger reduction in taxes rather than a different impact of the same tax on unobservables. Even though I cannot rule out this hypothesis, I can at least argue that given that the Italian fiscal framework takes into account the room count of a property (and not even all of the rooms) rather than the size. Thus there is scope for some variation in size with no change in the property tax levied on a property.

To further test the mechanism we can report the same result for a set of subsamples of the dataset. In particular, I will run the same regression as specified in equation 1 for the four largest cities of the nine included in the dataset: Rome, Milan, Turin, and Palermo. These are four of the five largest Italian town and geographically dispersed around the country. The results are summarized in tables 5 and 6.

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

Table 5: Table of Results: Rome and Milan.

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

Table 6: Table of Results: Turin and Palermo.

Columns (1) and (2) of table 5 refer, respectively, to the lower bound and the higher bound of Roman residential properties prices. Analogously, columns (3) and (4) of the same table refer to Milanese prices. Columns (1) and (2) of table 6 refer to Turinese prices, and (3) and (4) of the same table to Palermitan prices. Given the reduces sample of observation, the noise inevitably increases and the results are less precise. For this reason I am not clustering the standard errors. In any case the general picture is consistent with the national results. For Rome, Turin and Palermo we observe the same pattern as at the national level, where the capitalization of the property tax at the higher bound is higher than the lower one. This is particularly true for Rome where we have a higher number of observations and we cans safely exclude the null hypothesis that the two values are the same. The picture is slightly different for Milan, where the capitalization is higher at the lower bound of the distribution, but only slightly and with large confidence interval. As such I don't regard it as a strong evidence against the other results.

I can now turn to the policy impact analysis as specified in equation 2. As before I report first the national analysis in figures 1 and 2.

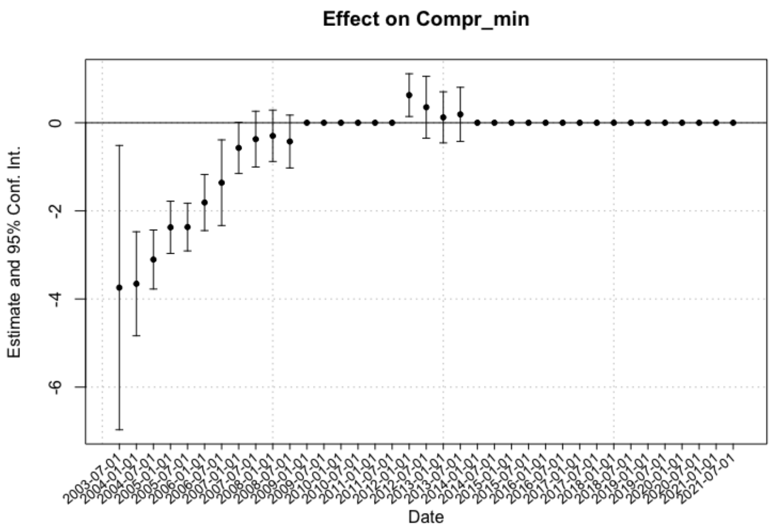

Figure 1: Policy impact on the lower bound at the national level

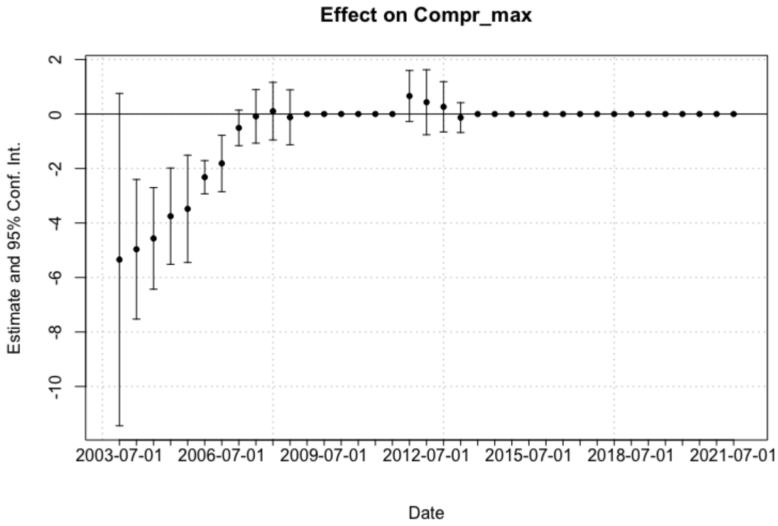

Figure 2: Policy impact on the upper bound at the national level

As in the previous analysis, it is possible to observe that before the first policy intervention (the one set be the fourth Berlusconi government in 2008) residential property prices capitalized the property tax. Additionally, the upper bound of property prices faces a larger reduction than the lower one at every period. We can further dive in the trend of property prices. First, the effect of the property tax is present in the period 2003-2008, while it is less clear in the period 2012-2014. It is possible that the political and economic turbulence of the early 2010s led to a lower capitalization of the tax. Let us then focus of the 2003-2008 period. There seems to be an upward trend in the residential property prices tied to the assessment of the property, and thus on the tax. In particular, in the two years before there seems to be no effect on the residential property prices of the property tax. As described in section III, the increase in prices between the first semester of 2006 and that of 2007 aligns with the public Berlusconi announcement that the centre-right coalition would adopt the abolition of the property tax on the main residences as their flagship policy. Given that the second Prodi government, in charge between the second half of 2006 until the beginning of 2008, was particularly precarious, it seems reasonable that homebuyers and homesellers started to price in the reduction in taxes starting from 2006 and expecting a centre-right government in the following years.[11] It is possible that the absence of capitalization in the period between 2012 and 2014 was

[11]The second Prodi government was a precarious government composed by seven parties large enough to form a group in the Senate and several others that did not reach that threshold, plus the support of other nine parties as

also due to the public considering the tax as temporary.[12] Lastly, the high confidence interval for the year 2003 is due to the low amount of observations regarding civilian properties for that year.

If we delve in the same analysis for the four main cities considered in the sample we observe a similar pattern.[13] In all cities we observe an upward trend in the period 2003-2008, with a specific increase around the period 2006-2007. Excluding Milan, where the pattern is mixed, the effect of the property tax is higher on the upper bound of prices than on the lower one. Lastly, an interesting trend that is particularly clear in the cases of Turin and Palermo, in the 2012-2014 period there seems to be a down-ward trend of prices which supports the hypothesis that the tax took time to be capitalized, possibly due to the correctly perceived temporary political equilibrium in favour of the tax.[14]

5.3 Robustness Checks

As described before in the data section, the OMI areas are updated every 10 years. This has happened once, in 2014, and thus the location fixed effects in the main analysis also capture some time trend. Given that the change happened concurrently to one of the policy changes of interest, I try the same analysis as before but I restrict the time frame to the 2003-2014 period. The results are shown in table 7.

Prices	(1)	(2)
Tariffa d'estimo	-1.042^{***}	-1.406^{***}
	(0.117)	(0.179)
N	13437	13437
R^2	0.974	0.968
Bound	Lower	Upper

Table 7: Table of Results: National (2003-2013).

As before column (1) reports the coefficient for the lower bound of residential property prices, while column (2) reports the same result for the upper bound. The coefficients are similar to the

external supporters. Given that the government had a majority of 10 senators at the beginning of the legislature, it is clear why the government lasted less than two years, including the care-taking period in 2008.

[12]Berlusconi did campaign against the reintroduction of the property tax, even though his party supported the Monti government.

[13]The figures are in the appendix.

[14]The specific results are reported in the appendix in figures from 13 to 16

one obtained in the previous subsection. In tables 13 and 14, reported in the appendix, I replicate the analysis of the four main cities with the reduced sample. Again, I obtain the same results.

A possible alternative explanation for the results is that what we are capturing is not the effect of the policy intervention regarding the property tax, but the different trends in property prices within the Italian cities. Let us suppose that in the period between 2003 and 2021, properties at the center of the respective cities were traded at increasingly higher prices relative to the other ones. Given that properties have higher *tariffe d'estimo* when they are closer to the respective city centre, the two factors are not orthogonal to each other. As a first test I run the same regression as in equation 1 considering only the first two *zone censuarie*, the central ones, for the city of Rome. The selection of Rome, which has several *zone censuarie* and a large number of OMI areas, enables me to focus on differences on taxation within the city centre. While the first *zona censuaria* of Rome covers the city centre, the second one still covers wealthy areas with high property prices such as Trastevere, Rione Prati and the area surrounding La Sapienza university. The results are reported in table 8.

Prices	(1)	(2)
Tariffa d'estimo	-5.391^{***}	-11.631^{***}
	(0.412)	(0.549)
N	953	953
R^2	0.977	0.978
Bound	Lower	Upper

Table 8: Table of Results: Excluding the peripheries (Rome).

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

To further control for these trends I run the following specification

$$\text{Price}_{t,o,l,q,r} = \alpha + \mathbb{1}(\text{Tax on main residences}) * \beta_o * \text{Tariffa d'Estimo}_{o,l} + \gamma_o + \gamma_t + \gamma_{c,t} + \gamma_{r,t} + \gamma_q. \quad (3)$$

Where the additional term $\gamma_{r,t}$ indicates a time-relative location within a city set of fixed effects. As reported in the data section, the OMI analysis associates to each of the OMI areas a letter indicating the relative position of the area within a city.[15] The results of the new specification are reported in table 9.

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

Table 9: Table of Results: Including within cities time trends.

In columns (1) and (2) I report the results, respectively for the lower and upper bounds, for the regression 3. With these specifications we still observe the effect of the capitalization, but the difference between the coefficients relative to the lower and upper bounds disappears. To check for the robustness of this last result, I restrict the analysis in columns (3) and (4) to the city of Rome. Here the difference reappears but the magnitude is lower than the results reported in tables 5 and 6, suggesting that the previous equations were not distinguishing between within city time trends and the policy impact. Lastly, given the results of tables 5 and 6 where the city of Milan was the only one that did not display a sizable difference between the lower and upper bounds point estimate, I try running the same regression as before, excluding Milan. The results are reported in columns (5) and (6) where the results are consistent with the previous results.[16]

5.4 Additional Results

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

[15] Central, semi-central, peripheral, sub-urban, and extra-urban.

[16] It is not clear, at the moment, why Milan would display different results other than chance.

tax influences capital allocation across jurisdiction it must do so as well across different types of property, and such effect should be captured in the different prices.

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

With the current data it is not possible to distinguish between the two channels, but it is possible to use the same econometric specification of equation 3 to test whether these second order effects are present. In tables 10 and 11 I report the results for the following categories: offices, warehouses, shops, garages, laboratories, and industrial sheds.

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

Table 10: Table of Results: National for offices, warehouses, and garages

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

Table 11: Table of Results: National for shops, laboratories, and industrial sheds

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

Another possible channel for distortion, that is consistent with the capital-tax view, is a shift in the supply of rented residential properties, relative to the ones that are sold. Again, an increase in residential property prices due to an increase in demand, will affect the decision of property-owners on whether to rent or sell their properties. The change in supply should affect their prices. I run the same regression as specified in equation 3 and I report the results in table 12.

Rents	(1)	(2)	(3)	(4)
Tariffa d'estimo	−0.024	0.025	−0.007	−0.055
	(0.017)	(0.019)	(0.052)	(0.064)
N	22542	22542	8677	8677
R^2	0.603	0.493	0.6	0.419
City	National	National	Rome	Rome
Bound	Lower	Upper	Lower	Upper

Table 12: Table of Results: Rents.

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

6 Model

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

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

6.1 Baseline Model

The model is composed by three types of agents arranged on a line representing the distance from the central business district of an urban agglomeration. Households decide where to reside in and commute to the central business district supplying their unit labor inelastically. Additionally they decide which type of housing to reside in and how much of a consumption good to consume. Producers decide how much labor and capital to use in order to produce the consumption good. Lastly, the capital owners supply their capital either to the production of the two types of housing or to the producers. As usual the equilibrium conditions close the model.

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

$$\begin{aligned} \text{Min}_{L,Q^d} \quad & wL + rQ^d. \\ \text{S.t.} \quad & x^s = P(L, Q^d). \end{aligned} \tag{4}$$

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

$$P_L(L, Q^d) = w. \tag{5}$$

$$P_Q(L, Q^d) = r. \tag{6}$$

The city is composed by N Households, which have several choices to make. First, they have to choose whether to consume housing with more or less unobservables. Where houses with more unobservables provide higher utility, everything else constant. Second, they need to choose where to locate themselves within the city, and thus the cost of commuting. Lastly, they have to decide their consumption bundle, between the consumption good and housing. All agents have the same utility function $U(H_h^d(t), H_l^d(t), x^d(t)) \geq 0$ which has the following specification

$$\begin{aligned} U(H_h^d(t), H_l^d(t), x^d(t)) = \mathbb{1}(H_h^d(t) > 0)(1 - \mathbb{1}(H_l^d(t) > 0))\, u^h(H_h^d(t), x^d(t)) \\ + \mathbb{1}(H_l^d(t) > 0)(1 - \mathbb{1}(H_h^d(t) > 0))\, u^h(H_l^d(t), x^d(t)) \end{aligned} \tag{7}$$

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

$$U(0, H_l^d(t), x^d(t)) = U(H_h^d(t), 0, x^d(t)) = U(H_h^d(t), H_l^d(t), 0) = 0 \tag{8}$$

Given the generality of the production function for housing in equation (22), H_q^d can indicate both the size of the house and the observable quality. The difference between observable and unobservable features will be important once we set up the fiscal framework in the following subsection. The two functions defined as $u_q^d(H_q^d(t), x^d(t))$ are both monotone increasing functions in both terms, with monotone decreasing first derivatives in both inputs. The function is defined such that housing and consumption are both normal goods. Furthermore the second derivatives are set as follows

$$\frac{\partial^2 u^q(H,x)}{\partial H^2} \leq 0 \tag{9}$$

$$\frac{\partial^2 u^q(H,x)}{\partial x^2} \leq 0 \tag{10}$$

$$\frac{\partial^2 u^q(H,x)}{\partial H \partial x} \geq 0 \tag{11}$$

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

$$u^h(H,x) \geq u^l(H,x) \tag{12}$$

And

$$\frac{\partial u^h(H,x)}{\partial H} > \frac{\partial u^l(H,x)}{\partial H} \tag{13}$$

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

$$\frac{\partial u^h(H,x)}{\partial H}\frac{\partial u^l(H,x)}{\partial x} > \frac{\partial u^l(H,x)}{\partial H}\frac{\partial u^h(H,x)}{\partial x} \tag{14}$$

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

The utility function captures the fact that an household only buys a single property of a specific level of unobservables q. Given that it is always preferable for an household to buy a single type of property it is possible to define two different problems: one for the households that acquire properties of $q = l$ and one for those who buy properties with $q = h$. An indifference condition, defined later in this section with equation (28), guarantees the equilibrium among the agents. Additionally, given that the two types of agents might pick different amount of consumption goods at the same location I define the following decomposition.

$$x^d(t) = x_h^d(t) + x_l^d(t) \tag{15}$$

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

$$\begin{aligned} \text{Max}_{x_q^d(t), H_q^d(t), t} \quad & u^q(x_q^d(t), H_q^d(t)). \\ \text{S.t.} \quad & w - k(t) = p x_q^d(t) + p^q(t) H_q^d(t). \end{aligned} \tag{16}$$

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

Solving the problem we obtain the two following conditions

$$\frac{p^q(t)}{p} = \frac{u^q_{H_q^d(t)}(x_q^d(t), H_q^d(t))}{u^q_{x_q^d}(x_q^d(t), H_q^d(t))} \quad \forall\, q \in \{h, l\} \wedge \forall\, t. \tag{17}$$

$$w - k(t) = p x_q^d(t) + p^q(t) H_q^d(t) \quad \forall\, q \in \{h, l\}. \tag{18}$$

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

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

$$\text{Max}_{H_h^s(t), H_l^s(t), Q^s} \quad \int_0^T [(p^h(t) H_h^s(t) - C_h(H_h^s(t), r_l(t)) + (p^l(t) H_l^s(t) - C_l(H_l^s(t), r_l(t)))] dt + Q^s r - C(Q^s). \tag{19}$$

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

$$p^h(t) = \frac{\partial C_h(H_h^s(t), r_l(t))}{\partial H_h^s(t)} \quad \forall\, t. \tag{20}$$

$$p^l(t) = \frac{\partial C_l(H_l^s(t), r_l(t))}{\partial H_l^s(t)} \quad \forall\, t. \tag{21}$$

$$r = \frac{\partial C(Q^s)}{\partial Q^s}. \tag{22}$$

We can now close the model by setting the equilibrium conditions. At equilibrium we have $\{L, Q^d, Q^s, x^d(t), x^s(t), H_l^s(t), H_h^s(t), H_l^d(t), H_h^d(t)\}$ such that equations (5) - (6) - (17) - (18) - (20) - (21) - (22) all hold for all locations t. Additionally $\{w, r, r_l(t), p^l(t), p^h(t), p\}$ such that all consumption goods are consumed in the city

$$\int_0^T x^d(t)dt = x^s = P(L, Q^d). \tag{23}$$

All citizens are hired

$$N = L. \tag{24}$$

The production capital market clears

$$Q^d = Q^s. \tag{25}$$

Both housing markets clear

$$H_h^s(t) = H_h^d(t) \quad \forall\, t. \tag{26}$$

$$H_l^s(t) = H_l^d(t) \quad \forall\, t. \tag{27}$$

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

$$u^q(H_q^d(t), x^d(t)) = \bar{u} \quad \forall\, t. \tag{28}$$

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

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

$$r_l(T) = r_a. \tag{29}$$

I can state the formal definition of the equilibrium.

Definition 1. *I define the equilibrium as a set of variables* $\{L, Q^d, Q^s, H_l^s(t), H_l^d(t), H_h^d(t), H_l^s(t), H_h^s(t), x_l^d(t), x_h^d(t)\}$ *such that the household problem 16, the producer problem 4, and the capital owner problem 19 are optimized at all locations, given the vector of prices, and the amount of consumption goods provided. The vector of prices, market goods supplied, utility level, and city size* $\{w, r, r_l(t), p^l(t), p^h(t), p, x^s(t), \bar{u}, T\}$ *is set such that the markets for labor, capital, consumption goods, and housing all clear, as equations (24) - (23) - (25) - (27) - (26) hold at all locations, given the city size. Lastly, households are indifferent between locations, as equation (28 holds for all* $t \in [0, T]$ *and the city boundary is defined by (29).*

We can now formally state Proposition 1 which states a sufficient condition for the existence of the equilibrium.

Proposition 1. *Consider the following conditions*

1. *The derivative of the utility function is continuous for all arguments.*
2. *Considering the equilibrium conditions* (17) - (18) - (20) - (21) - (29)*, the utility functions are either such that*

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

and, for $p \to \infty$

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

or if the inequality directions are inverted.

In case, instead, that

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

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

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

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

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

Conditions 2 and 3 ensure that there exist a value p such that at $t = T$ the system of equations described by (28) with unknown p and $\bar{u}$ has a set of internal solutions. Analogously, conditions 4 and 5 guarantee the existence of $r(t)$ for each t. For example it is the case of a Cobb-Douglas utility function with the same parameters, and as such there is either no solution to the system of equations that defines the equilibrium or there are infinite.

Proof. First we can simplify notation by noticing that the market clearing conditions (25) - (27) - 26 ensue that demand and supply match. As such we can write $H_q^d(t) = H_q^s = H^q(t)$ and $Q^s = Q^d = Q$.

Now it is easy to determine the variables that solve the producer problem. Notice that L is pinned down by equation (24). Second, considering equations (22) and (6), we can determine Q and r. Lastly, through equation (5) we can determine w.

We can now turn to the remaining variables. First let us consider the case of $t = T$. Then equation (29) sets the land rent at the border. Then equations (17)-(18)-(20)-(21) will fix $H^h(T), H^l(T), x^l(T), x^h(T), p^l(T)$, and $p^h(T)$ as functions of T and p. Then we can set p such that (28) holds for both levels of unobservables thanks to the intermediate value theorem. To see why, consider the cases under which $p = 0$ or $p \to \infty$. Under both cases the utilities are both equal to 0. If either condition 2 holds, then according to the intermediate value theorem there must be at least an internal crossing between the two functions.

Having determined p and $\bar{u}$, we can now use equations (17)-(18)-(20)-(21)-(28) to fix $H^h(t), H^l(t)$, $x^l(t), x^h(t), p^l(t), p^h(t)$, and $r_l(t)$ for all locations. With a process analogous to the one above.

Lastly, the total size of the city is determined uniquely by equation 23 and by the intermediate value theorem. □

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

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

Proof. I will consider the two cases $p^h(t) < p^l(t)$ and $p^h(t) = p^l(t)$.
Let us first consider the latter. Given that the two types of household have the same budget constraint, it follows from equations (17) - (18) that $H^h(t) > H^l(t)$. To see why consider the following equations that holds at equilibrium due to $p^h(t) = p^l(t)$

$$\frac{u^h_{H^h(t)}(x^h(t), H^h(t))}{u^h_{x^h(t)}(x^h(t), H^h(t))} = \frac{u^l_{H^l(t)}(x^l(t), H^l(t))}{u^l_{x^l(t)}(x^l(t), H^l(t))}$$

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

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

$$\frac{u^h_{H^h(t)}(x^h(t), H^h(t))}{u^h_{x^h(t)}(x^h(t), H^h(t))} < \frac{u^l_{H^l(t)}(x^l(t), H^l(t))}{u^l_{x^l(t)}(x^l(t), H^l(t))}$$

But given the condition imposed on the utility functions expressed by (14) and by (9) - (10) - (11), it must be that the inequality has the opposite sign. As such it is impossible that the demand side inequality holds and that $p^l(t) > p^h(t)$. □

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

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

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

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

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

$$u^h(t) = [(aH^h(t))^{\frac{\sigma-1}{\sigma}} + x^h(t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{1-\sigma}} \tag{30}$$

$$u^l(t) = [H^l(t)^{\frac{\sigma-1}{\sigma}} + x^l(t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{1-\sigma}} \tag{31}$$

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

Regarding the cost of providing the housing good we have

$$C^h(H^h(t), r_l(t)) = H^h(t)^c r_l(t) \tag{32}$$

$$C^l(H^l(t), r_l(t)) = H^l(t) r_l(t) \tag{33}$$

With $c > 1$. Having defined these functional forms I can now provide some further results. First, I will define the object of interest which is the ratio of prices of a property given a location t. Consider the supply side equations (20) - (21). The ratio gives us

$$\frac{p^h(t)}{p^l(t)} = cH^h(t)^{c-1} \tag{34}$$

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

I can now express the three equations defining the equilibrium values of $H^h(t)$, $H^l(t)$, p, and $r_l(t)$ given T. First we can use equations (17) - (18) - (20) - (21) to obtain the following two equations

$$w - k(t) = c\, r_l(t)\, H^h(t)^c + \frac{(c\, r_l(t))^\sigma}{(a\, p)^{\sigma-1}} H^h(t)^{1+\sigma(c-1)} \tag{35}$$

$$w - k(t) = H^l(t)\Big(1 + \Big(\frac{r_l(t)}{p}\Big)^{\sigma-1}\Big) \tag{36}$$

Lastly the indifference condition (28) leads to the following condition

$$(a\, p)^{\frac{\sigma-1}{\sigma}} H^h(t)^{\frac{\sigma-1}{\sigma}} + (w - k(t) - c\, r_l(t) H^h(t)^c)^{\frac{\sigma-1}{\sigma}} = p^{\frac{\sigma-1}{\sigma}} H^l(t)^{\frac{\sigma-1}{\sigma}} + (w - k(t) - r_l(t) H^l(t))^{\frac{\sigma-1}{\sigma}} \tag{37}$$

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

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

6.2 Fiscal Framework

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

$$u_g^q(x^d(t), H_q^d(t), g) = gu^q(x^d(t), H_q^d(t)). \tag{38}$$

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

$$\begin{aligned} \text{Max}_{x_q^d(t), H_q^d(t), t} \quad & gu^q(x^d(t), H_q^d(t)). \\ \text{S.t.} \quad & w - k(t) - \tau(H_q^d(t), t) = px^d(t) + p^q(t)H_q^d(t). \end{aligned} \tag{39}$$

Which is solved when

$$\frac{p^q(t)}{p} = \frac{u^q_{H_q^d(t)}(x_q^d(t), H_q^d(t))}{u^q_{x_q^d}(x_q^d(t), H_q^d(t))} \quad \forall q \in \{h, l\} \land \forall t. \tag{40}$$

$$w - k(t) - \tau(H_q^d(t), t) = px_q^d(t) + p^q(t)H_q^d(t) \quad \forall q \in \{h, l\}. \tag{41}$$

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

$$G = P_g(N, \tau(H_q^d(t), t), T). \tag{42}$$

Which is then redistributed across individuals equally

$$Ng = G. \tag{43}$$

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

Before moving to the three specific fiscal scenarios taken under consideration, it is important to stress two technical points regarding the modelization choices. The first one, regards the static nature of the model. The model considers consumers who face an irreversible locational choice. Agents decide once where to live and pay a form of housing ticket and the corresponding tax affects the cost of this ticket. I abstract from the choice between renting or buying a house, which is inter-temporal in nature. It can be stressed that with a modelization trick it is possible to introduce some simplified form of intertemporal decision in a static world.[17] Consider, a situation where an agent can choose whether to buy a house or keep renting in the same location for sufficiently long time period. In this case the future expenditure weighted by the intertemporal discount factor, will be equal to the cost of a house with the same level of unobservables in the same location. If this were not the case, the agents would shift between contracts until the same utility levels are guaranteed across locations, levels of unobservables and contract types. Similarly the public good provided and the taxes due can be collapsed into a current value term.

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

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

The poll tax scenario has the simple following fiscal specification

$$\tau(H_q^d(t), t) = \tau. \tag{44}$$

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

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

[17] Or expected to remain static.

$$\tau(H_q^d(t), t) = \tau(t). \tag{45}$$

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

$$\frac{\partial \tau(t)}{\partial t} \leq 0. \tag{46}$$

Which in words means that, as a property is located further to the city centre, the tax due remains equal or decreasing. It is a scenario partially compatible with that of the Italian IMU, if we consider a single city.[18]

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

$$\tau(H_q^d(t), t) = \tau(H_q^d(t)). \tag{47}$$

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

$$\tau(H_h^d(t), t) = \tau(H_l^d(t)) \quad \forall\, t. \tag{48}$$

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

$$\tau(H_h^d(t), t) = \tau\, H_l^d(t) \quad \text{with } \tau \in (0, 1). \tag{49}$$

With respect to the poll tax, the main effect will be to shift downward the income of every agent in the city equally. Given that both goods are normal goods by assumption, the tax would initially reduce consumption of the three goods, the common consumption one and the two types of housing. The equilibrium effects are less clear.In particular it is not clear the effect of an increase of income on p which depends on the first order demand effect of the two types of households and equation (37). Given that the equilibrium effect of a tax change on the level of the consumption good price p is ambiguous, there are parameters and equilibria such that an increase in the tax,

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

actually increases the consumption in housing and consequently the price dispersion. A sufficient condition for a decreasing price dispersion is that a tax increase leads to a consumption good price decrease. This theoretical result is in contradiction with the results of both Hamilton and Zodrow, which argue that property taxes, which are a less extreme version of poll taxes, lead to less dispersion in the house prices. The main reason for this result is that, contrary to previous models, we are assuming the indifference condition (28). Compared to the previous models, the one presented here has an additional channel for internalizing changes in taxation which is households changing the type of housing consumed.

Regarding the location tax described by equation (45) the most consequence regards the interaction with lemma 2. Given a specific t the consequences of the tax is similar to the ones of the poll tax and, thus, I will not focus in it. Consider, instead, the difference between different locations across the city under consideration. Lemma 2 indicates that housing consumption increases as t increases, while the consumption good decreases. Once this locational tax is introduced there is an additional condition that must be added to lemma 2. The lemma applies if the effective income $w - k(t) - \tau(t)$ is decreasing in t. The process is mediated by the increase in $p^q(t)$ as the distance from the central business district increases. As the progressivity of the property tax increases and the dispersion of the effective income $w - k(t)$ decreases, the geographic dispersion must decrease in order to maintain the indifference condition. Two cases are interesting enough to be considered individually. First there is the degenerate case under which the effective income is constant. Under this set up, the locational differences within the city are levelled out and as such $H^q(t) = H^q$, $x^q(t) = x^q$, and $r_l(t) = r_a$ for all $q \in \{l, h\}$ and all $t \in [0, T]$. The second set up is the one under which the effective income is increasing in distance.

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

The third type of tax rather than affecting the effective income, it influences the price ratio between real estate properties and the consumption good captured by equations (40). As in the case of the poll tax, the effect of a change in the tax depends crucially on the changes on the consumption good price. If a positive change in the property tax leads to positive change in p, then we have a fall in $H^d(t)$, which, in the CES utility setting, implies a fall in the price dispersion. An opposite effect on p has more ambiguous consequences.

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

7 Conclusion

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

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

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

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

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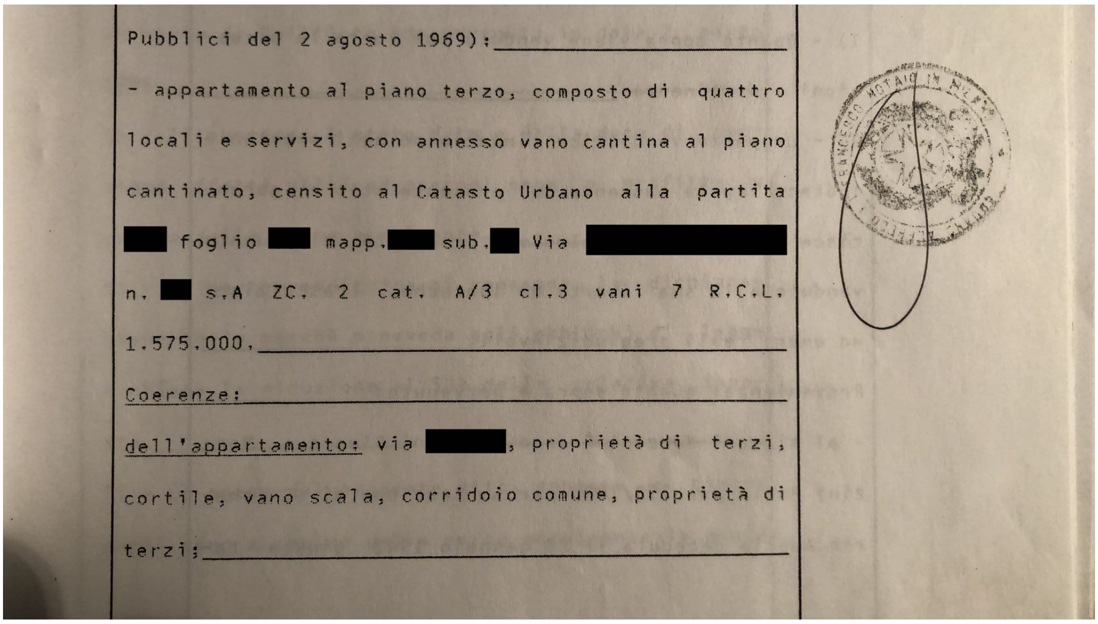
Appendix

A Example of a Deed

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



Pubblici del 2 agosto 1969):

- appartamento al piano terzo, composto di quattro locali e servizi, con annesso vano cantina al piano cantinato, censito al Catasto Urbano alla partita [redacted] foglio [redacted] mapp.[redacted] sub.[redacted] Via [redacted] n. [redacted] s.A ZC. 2 cat. A/3 cl.3 vani 7 R.C.L. 1.575.000.

Coerenze:

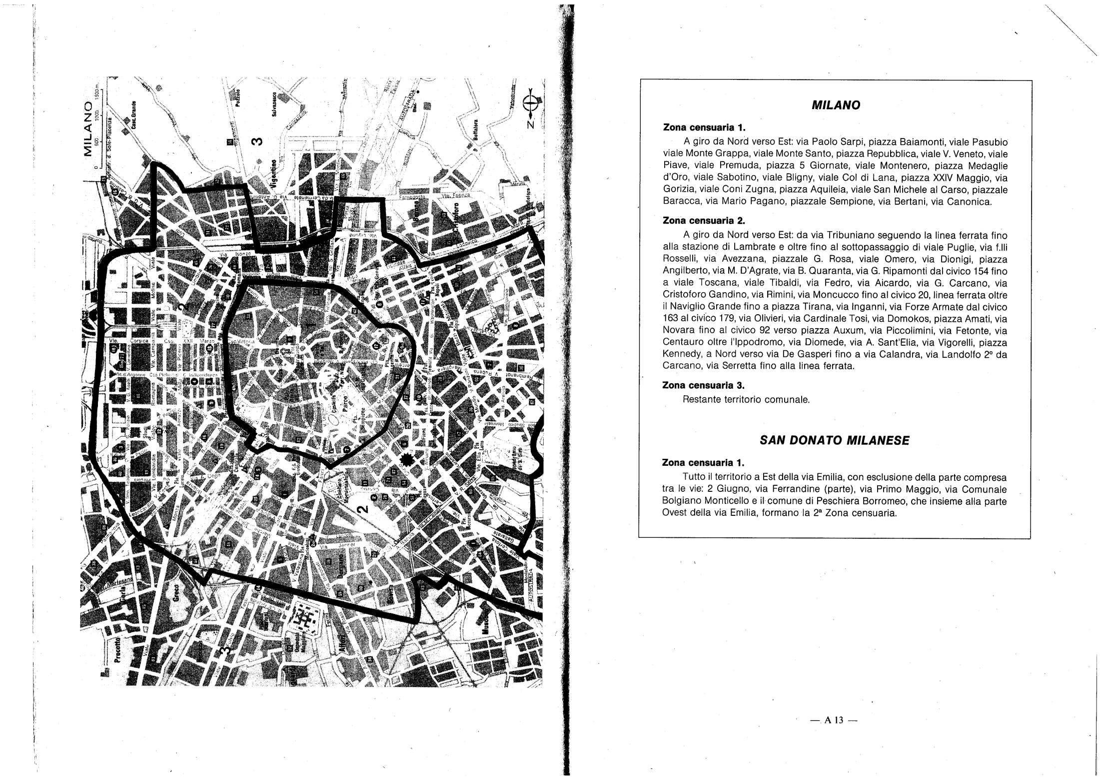
dell'appartamento: via [redacted], proprietà di terzi, cortile, vano scala, corridoio comune, proprietà di terzi;

Figure 3: Example of a deed.

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

B Drawing the *Zone Censuarie*

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



MILANO

Zona censuaria 1.

A giro da Nord verso Est: via Paolo Sarpi, piazza Baiamonti, viale Pasubio viale Monte Grappa, viale Monte Santo, piazza Repubblica, viale V. Veneto, viale Piave, viale Premuda, piazza 5 Giornate, viale Montenero, piazza Medaglie d'Oro, viale Sabotino, viale Bligny, viale Col di Lana, piazza XXIV Maggio, via Gorizia, viale Coni Zugna, piazza Aquileia, viale San Michele al Carso, piazzale Baracca, via Mario Pagano, piazzale Sempione, via Bertani, via Canonica.

Zona censuaria 2.

A giro da Nord verso Est: da via Tribuniano seguendo la linea ferrata fino alla stazione di Lambrate e oltre fino al sottopassaggio di viale Puglie, via f.lli Rosselli, via Avezzana, piazzale G. Rosa, viale Omero, via Dionigi, piazza Angilberto, via M. D'Agrate, via B. Quaranta, via G. Ripamonti dal civico 154 fino a viale Toscana, viale Tibaldi, via Fedro, via Aicardo, via G. Carcano, via Cristoforo Gandino, via Rimini, via Moncucco fino al civico 20, linea ferrata oltre il Naviglio Grande fino a piazza Tirana, via Inganni, via Forze Armate dal civico 163 al civico 179, via Olivieri, via Cardinale Tosi, via Domokos, piazza Amati, via Novara fino al civico 92 verso piazza Auxum, via Piccolimini, via Fetonte, via Centauro oltre l'Ippodromo, via Diomede, via A. Sant'Elia, via Vigorelli, piazza Kennedy, a Nord verso via De Gasperi fino a via Calandra, via Landolfo 2° da Carcano, via Serretta fino alla linea ferrata.

Zona censuaria 3.

Restante territorio comunale.

SAN DONATO MILANESE

Zona censuaria 1.

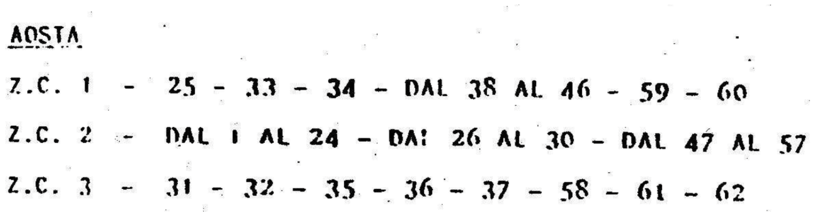
Tutto il territorio a Est della via Emilia, con esclusione della parte compresa tra le vie: 2 Giugno, via Ferrandine (parte), via Primo Maggio, via Comunale Bolgiano Monticello e il comune di Peschiera Borromeo, che insieme alla parte Ovest della via Emilia, formano la 2ª Zona censuaria.

— A 13 —

Figure 4: Map of the three *zone censuarie* and the streets of the boundaries

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

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



AOSTA

Z.C. 1 - 25 - 33 - 34 - DAL 38 AL 46 - 59 - 60

Z.C. 2 - DAL 1 AL 24 - DAL 26 AL 30 - DAL 47 AL 57

Z.C. 3 - 31 - 32 - 35 - 36 - 37 - 58 - 61 - 62

Figure 5: List of cadastral parcels per *zona censuaria* in Aosta.

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

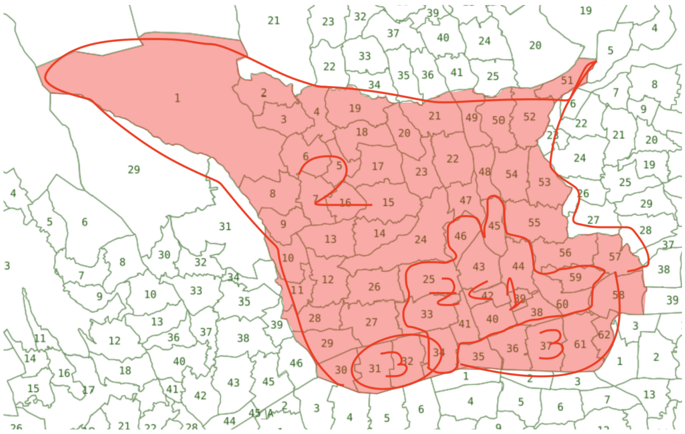


Figure 6: The different *zone censuarie* of Aosta.

Having, in both cases, a map of the *zone censuarie* it is then possible to draw them on QGIS. Figures 7 and 8 report the final results.

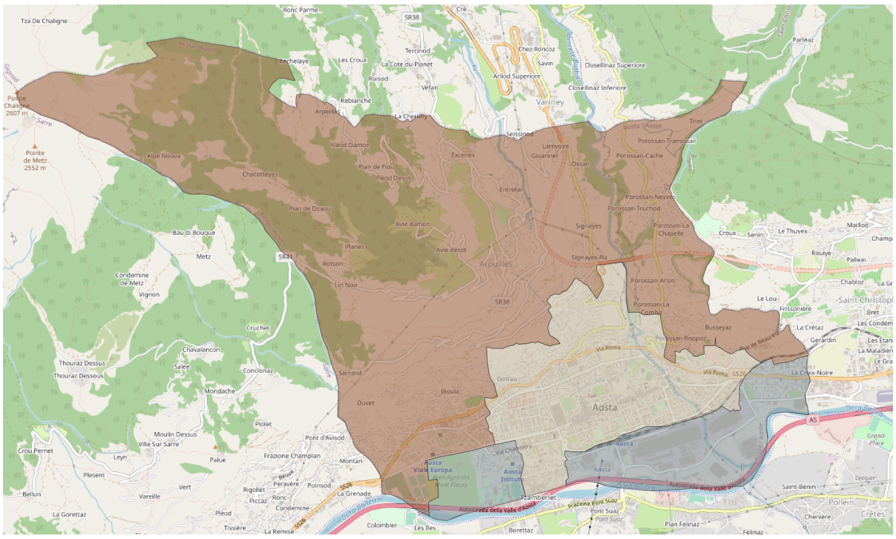


Figure 7: *Zone Censuarie* of Aosta.

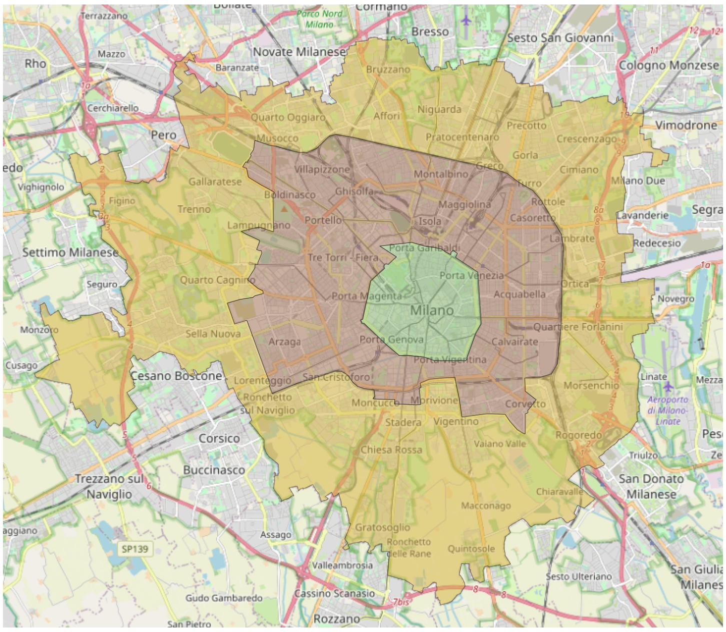


Figure 8: *Zone Censuarie* of Milan.

Superimposing the newly obtained maps of the *zone censuarie* and the polygon shapes of the OMI areas provided by the Osservatorio del Mercato Immobiliare, it is then possible to assign to each OMI area the corresponding *zona censuaria* and thus some estimate of the local property tax.

C Additional Results per City

C.1 Policy Impact on Individual Cities

In the following subsection I show the individual results of the policy impact analysis on the four main cities in the sample. Figures 9 and 10 report the results for Rome, figures 11 and 12 report the results for Milan, figures 13 and 14 reports the result for Turin, and, lastly, figures 15 and 16 report the results for Palermo.

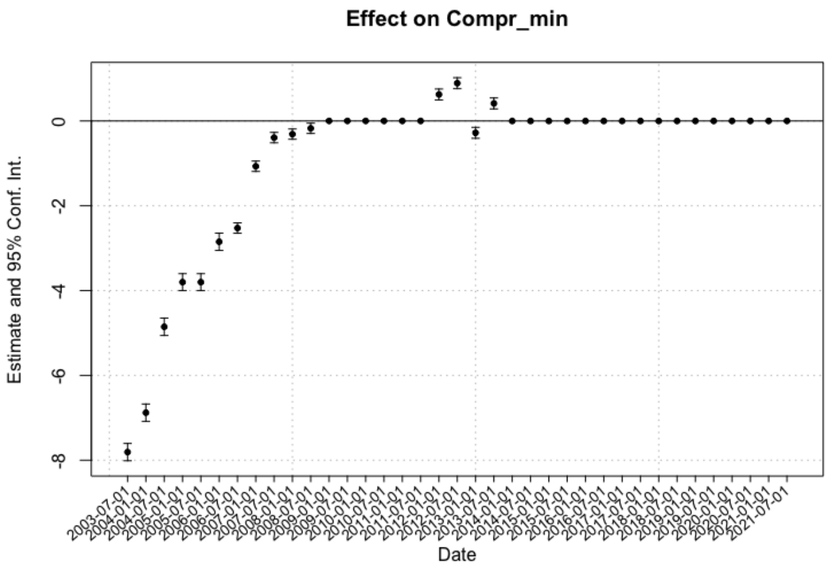


Figure 9: Policy impact on the lower bound for Rome.

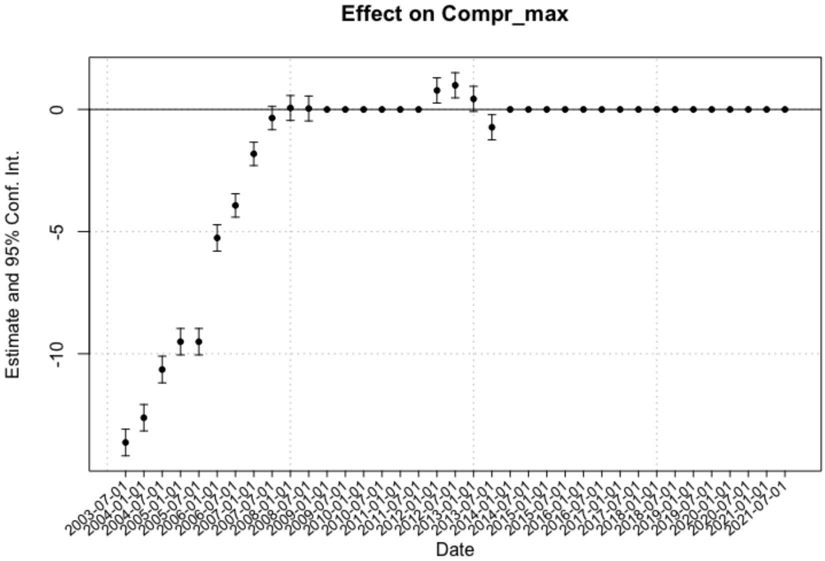


Figure 10: Policy impact on the upper bound for Rome.

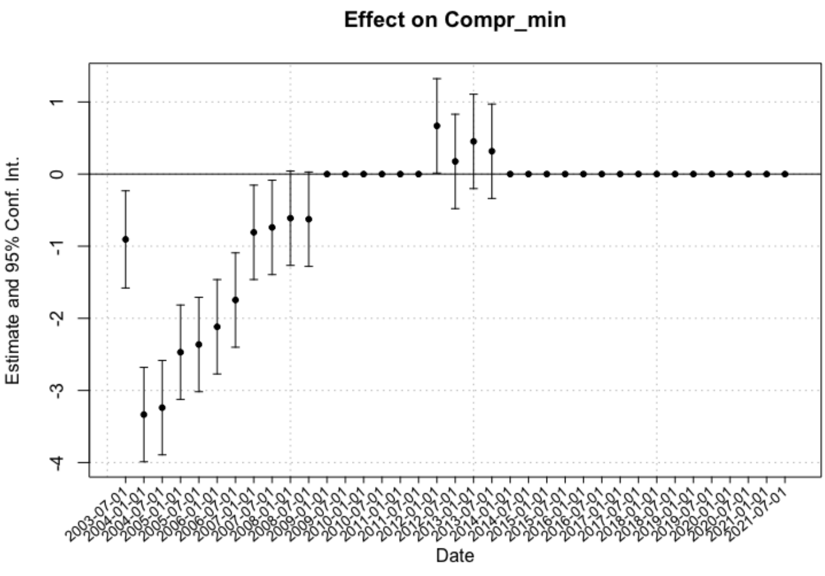


Figure 11: Policy impact on the upper bound for Milan.

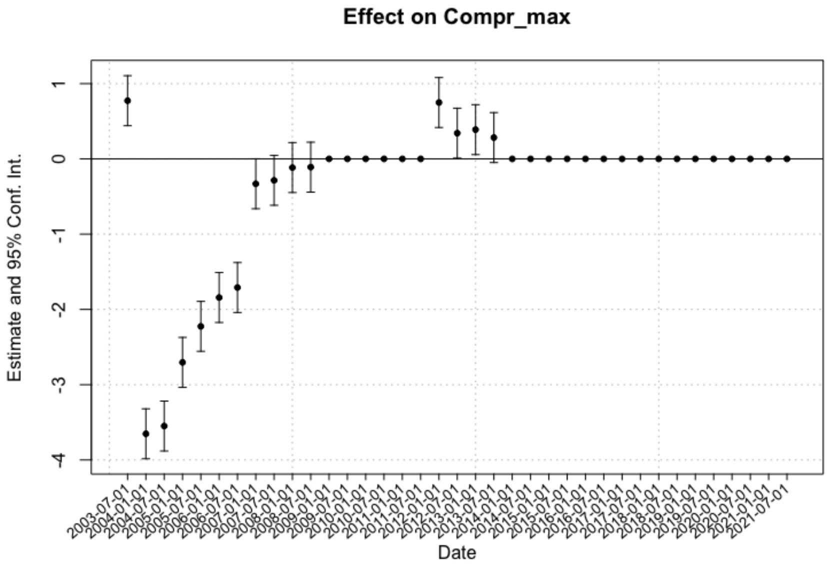


Figure 12: Policy impact on the upper bound for Milan.

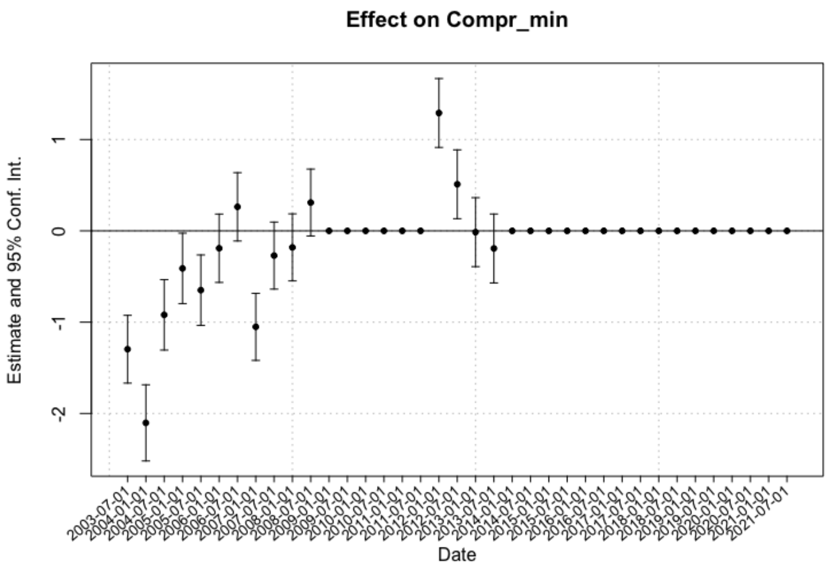


Figure 13: Policy impact on the lower bound for Turin.

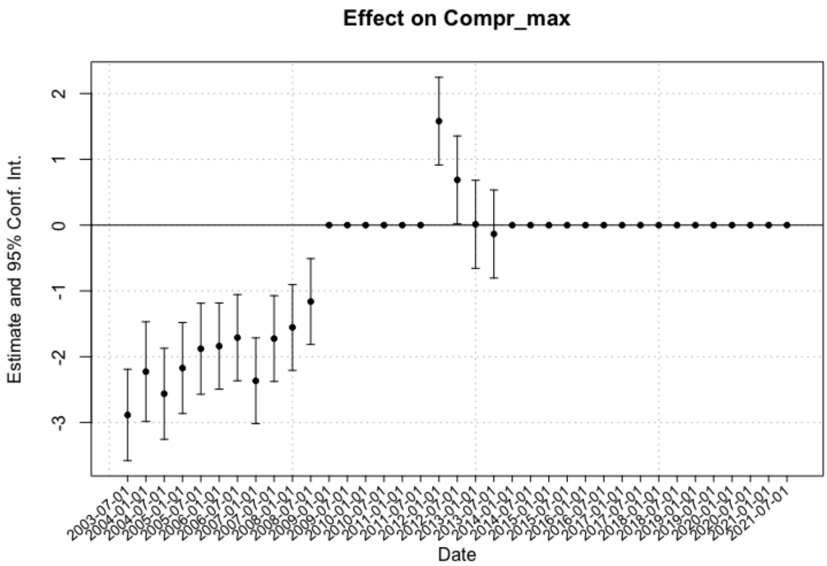


Figure 14: Policy impact on the upper bound for Turin.

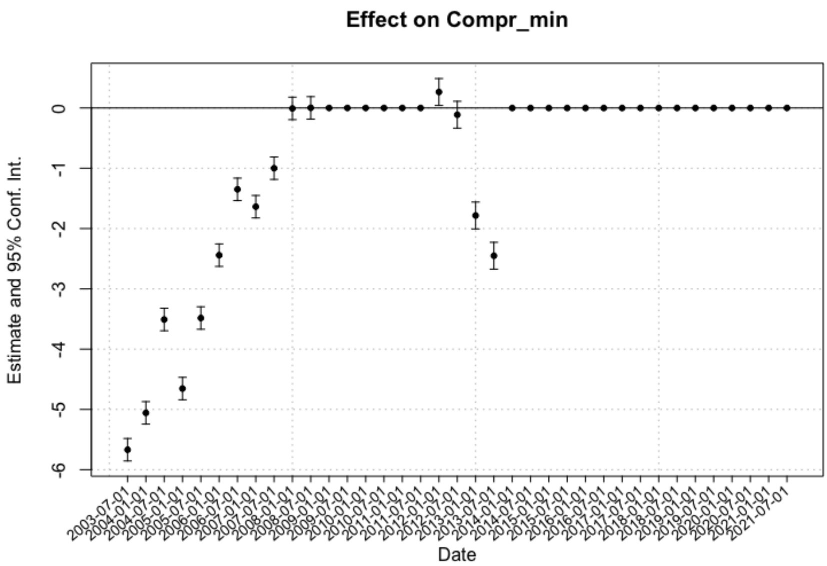


Figure 15: Policy impact on the lower bound for Palermo.

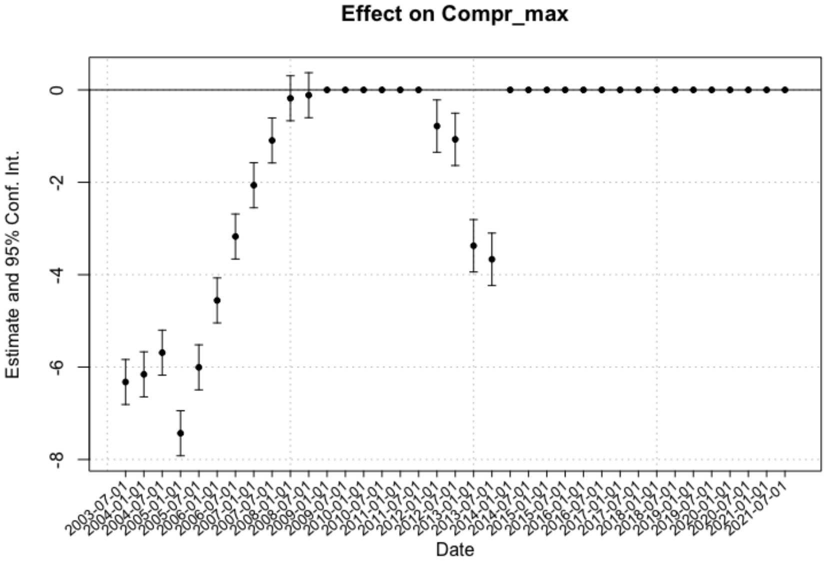


Figure 16: Policy impact on the upper bound for Palermo.

C.2 Robustness Checks on Individual Cities

In tables 13 and 14 I report the result of regression 1 when applied to a specific municipal subsample. As in tables 5 and 6, odd columns report the coefficient for the lower bound, while even columns report the result for the upper bound. Columns (1) and (2) of table 13 refer to Rome, columns (3) and (4) of the same table refer to Milan, columns (1) and (2) of table 14 refer to Turin, and, lastly, columns (3) and (4) of the latter table refer to Palermo.

Prices	(1)	(2)	(3)	(4)
Tariffa d'estimo	-1.461^{***}	-2.876^{***}	-1.169^{***}	-1.011^{***}
	(0.178)	(0.272)	(0.201)	(0.331)
N	5091	5091	3356	3356
R^2	0.979	0.973	0.970	0.955
Quality FE	No	No	Yes	Yes
City	Rome	Rome	Milan	Milan
Bound	Lower	Upper	Lower	Upper

Table 13: Table of Results: Rome and Milan (2003-2013).

Prices	(1)	(2)	(3)	(4)
Tariffa d'estimo	-0.321	-1.191^{*}	-2.130^{***}	-3.381^{***}
	(0.469)	(0.677)	(0.533)	(0.721)
N	961	961	990	990
R^2	0.912	0.918	0.963	0.962
Quality FE	Yes	Yes	No	No
City	Turin	Turin	Palermo	Palermo
Bound	Lower	Upper	Lower	Upper

Table 14: Table of Results: Turin and Palermo (2003-2013).