# Employment Fluctuations, Real Estate Prices, and Property Taxes [1]

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October 9, 2023

**Abstract**

This paper studies the role of real estate prices on employment fluctuations. We focus on the relative importance of the housing wealth and firm collateral channel on employment. We use empirical evidence from Italian municipality data and feature a quantitative model with financial frictions to quantify each channel. First, we exploit municipal-level variation in property tax changes to estimate its effect on labor, consumption, and real estate prices during Italy's 2012 property tax reform. Then, we use the estimates to calibrate a quantitative model that includes houses and commercial real estate charged with different property tax rates. We find that both channels explain more than 50% of the employment decline due to higher property taxes. However, the firm collateral channel reduces employment by 20% more than the housing wealth channel.

**Keywords:** employment growth, real estate prices, housing wealth, collateral, property taxes.
**JEL Codes:** E21, E24, K25, R31, R33, R51.

[1] I would like to thank Yan Bai, George Alessandria, and Narayana Kocherlakota for the insightful comments and suggestions. For further comments and suggestions, I thank Yasin Kürşat Önder, John Singleton, Kegon Tan, Gaston Chaumont, Ronni Pavan, and participants at the Workshop on Empirical Macroeconomics at Ghent University and 93rd IAEE Conference.

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# 1 Introduction

What are the employment consequences of a drop in real estate prices? This question gained considerable interest, especially in the aftermath of the 2007 US housing market bust. The literature argues that *housing wealth channel* can explain the negative impact on employment after a drop in residential prices (Mian and Sufi, 2014). Under this narrative, labor demand decreases because lower residential prices reduce consumption expenditure of financially constrained households, resulting in lower sales for firms dependent on the local market demand.

On the other hand, the literature also considers that a drop in commercial real estate prices affects employment through the *firm collateral channel* (Bahaj et al., 2022). In this case, lower prices for commercial real estate reduce the value of assets that firms use as collateral to obtain loans. As a result, financially constrained firms cut labor demand due to a drop in available financial resources to fund regular operations.

This paper studies the employment consequences of a simultaneous drop in residential and commercial real estate prices. We are particularly interested in the differential effect of real estate prices on employment through the housing wealth and firm collateral channels.

Understanding the relative magnitude of both channels on employment is important mainly due to its policy implications. For example, during the 2007 US housing crisis, the drop in real estate prices was followed by higher default rates for real estate-backed loans and higher loan-to-value ratios for residential and commercial real estate owners. US policymakers debated the appropriate measures to stabilize real estate prices, minimize job losses, and accelerate economic recovery (Hubbard and Mayer, 2009). One of the discussions was whether policy actions aimed at helping homeowners should also target commercial real estate owners facing foreclosure.[1] Measuring the relative importance of the housing wealth and firm collateral channel on employment should provide better guidance to answer policy questions of this nature.

However, quantifying each channel is a difficult task. In particular, we need to overcome two challenges. First, residential and commercial real estate prices are positively correlated (Piazzesi and Schneider, 2016), so it is unclear how we can separate both channels affecting employment similarly. Second, a drop in real estate prices affects labor through other mechanisms unrelated to the housing wealth and firm collateral channels; for example, lower residential prices increase labor supply through a wealth effect.

We address the previous issues by combining reduced-form estimates with a quantitative model. Our empirical approach exploits a differential increase in residential and

[1] See Panel (2010), Levitin (2009), and Marsh (2011).

commercial property taxes. As we argue later, changes in property taxes act as a specific shock to the demand of the real estate asset being taxed more heavily, reducing its price—all else constant. Additionally, we develop a quantitative model that, disciplined by our empirical evidence, allows us to measure each channel on employment.

Regarding our empirical approach, we employ novel municipal-level data for Italy during 2008-2014 to estimate the differential effect of higher residential and commercial real estate taxes during the 2012 property tax reform. We base our parametric specification on a Difference-in-Difference strategy. The change in tax rates for residential and commercial properties are used as treatment intensity variables. The outcome variables of interest are employment, consumption expenditure, and residential and commercial real estate prices. Our empirical results show that higher property taxes are associated with lower growth for non-tradable employment, consumption expenditure, and real estate prices.

In order to discipline the quantitative model with the estimates obtained from Italian data, we need to ensure that our empirical strategy correctly identifies the reduced-form effect of higher property taxes. Our diff-in-diff design points to two necessary conditions to identify the average treatment effect of higher property taxes in treated municipalities. First, municipalities should not anticipate the tax reform, so self-selection into different treatment intensities should be ruled out. Second, in a counterfactual scenario where property taxes do not change, the outcome trends should be parallel, irrespective of the actual tax increase chosen by a municipality during the tax reform.

We find no evidence that our diff-in-diff strategy violates the mentioned conditions. First, based on the events preceding the tax reform and the particularities of the Italian property tax system, we argue that local authorities could not anticipate the 2012 tax reform. Second, using an event-study analysis, we found no evidence of systematic differences in pre-tax reform trends for all outcomes across municipalities choosing different property tax changes in 2012.

Next, we build a general equilibrium model that includes both channels and mimics the main features of the Italian property tax system. The model includes residential and commercial real estate assets, a government defining a differential property tax rate, and loan collateral requirements for households and firms. The particular structure of our model creates two advantages. First, using the analytical solution for the model's equilibrium, we compute the differential response of employment, consumption, and real estate prices to higher property taxes that maps one-to-one with our diff-in-diff estimates. Second, we decompose the labor's response to higher property taxes into three parts; one capturing either the housing wealth channel–if residential taxes increase–or the firm collateral channel–if taxes for commercial properties increase, while the remaining parts representing adjustments of labor supply, and additional changes in labor demand due to a general equilibrium adjustment of prices and wages.

Finally, we discipline the model using the estimates obtained with Italian data. In our model, the real estate supply elasticities and the collateral requirements determine the relative importance of the housing wealth and the firm collateral channel. We calibrate these four parameters. Specifically, we calibrate the supply elasticity for residential properties and household collateral requirements to match the consumption and residential price response to higher residential taxes predicted by the model with the data counterpart estimates. On the other hand, we set the elasticity of supply for commercial properties and the firm's collateral requirement to equate the model-implied effect of higher commercial taxes on commercial and residential prices with the data estimates. Using our calibration, we compare the model's predictions for employment with the empirical counterparts. We find that our model does a reasonably good job replicating the employment estimates obtained with Italian data.

The main quantitative results of our model are twofold. First, the housing wealth and firm collateral channel explain more than 50% of the labor decline after a drop in real estate prices induced by higher property taxes. In particular, the model predicts that a one percentage point (pp) increase in the commercial properties tax rate reduces non-tradable employment growth by 0.061 pp with 70% (0.043 pp) of this decline explained by the collateral channel. In comparison, a one pp increase in the tax rate for houses reduces non-tradable employment growth by 0.071 pp with 51% (0.036 pp) of this decline explained by the housing wealth channel. Second, in terms of relative importance, the firm collateral channel seems to reduce employment by almost 20% more than the housing wealth channel after an increase in property taxes.

**Contribution to the Literature.** This paper is mainly related to recent empirical work in macroeconomics studying the housing cycle's impact on employment by exploiting regional variation in real estate wealth fluctuations. In particular, our paper is closely related to the seminal work on the housing wealth channel for employment done by Mian and Sufi (2014) and Guren et al. (2021), and the research about the firm collateral channel on employment in Adelino et al. (2015), Giroud and Mueller (2017), and Bahaj et al. (2022).

In the context of the recent US housing bust, Mian and Sufi (2014) show that non-tradable employment decreased relatively more in counties with a significant decline in housing prices. The previous analysis is extended and improved in Guren et al. (2021); they find that the importance of the housing wealth channel on employment during the US great recession is not explained by the higher sensitivity of economic activity to house prices but by the magnitude of house price movements in that period.

On the other hand, Adelino et al. (2015) shows that during 2002-2007, employment growth was more sensitive to changes in housing prices for small firms, which are more dependent on collateral to obtain loans from banks. Similarly, Bahaj et al. (2022) focuses on the importance of the firm owner's real estate assets as a source for collateral to estimate the heterogeneous effect of monetary policy on employment. The authors find that employment at younger, more-levered firms is more sensitive to monetary policy shocks. Finally, Giroud and Mueller (2017) uses micro-level data for US establishments and finds that declines in residential prices produce a greater negative effect on employment in establishments of highly leveraged firms and counties with a large share of highly leveraged firms.

Relative to the previous papers, our main contribution is to provide a unifying approach that measures both channels simultaneously. We combine a novel identification strategy based on property tax changes and use the estimated results to discipline a model to quantify each channel.

We also contribute to the literature that incorporates reduced-form estimates to general equilibrium models to measure unobservable channels affecting the economy. In particular, our paper is closely related to Chodorow-Reich et al. (2021), which measures the wealth effect on household consumption expenditure using reduced-form estimates of the employment response to changes in stock market wealth to inform a dynamic general equilibrium model. In contrast, our paper provides a closed-form decomposition linking reduced-form employment elasticities to local property tax changes with the housing wealth and firm collateral channel.

Finally, this paper contributes to previous empirical work on the macroeconomic effect of property taxes. The 2012 Italian property tax reform has been widely used in this literature. Two examples are Oliviero and Scognamiglio (2019) and Surico and Trezzi (2019). The former uses residential prices as the main outcome variable, while the latter focus on the response of consumption expenditure using Italian household survey data. Our empirical results for residential prices and consumption expenditure align with the findings of these papers. In addition, we provide new evidence on the effect of property taxes on non-tradable employment and commercial real estate prices.

**Layout.** The organization of the paper is as follows. Section 2 provides the intuition between changes in property taxes with the housing wealth and the firm collateral channel on employment. Section 3 summarizes the particularities of the 2012 property tax reform in Italy. Section 4 describes our novel municipal-level dataset for Italy. Section 5 presents the parametric specification and the conditions for identification in our diff-in-diff research design. Section 6 reports the baseline estimation results, discusses the potential threats to identification for our estimation strategy, and presents the evidence supporting its use for the 2012 tax reform in Italy. Section 7 describes the model's structure and characterizes the equilibrium of the economy, its response to changes in property taxes, and the link between the employment response to property tax changes and the housing wealth and the firm collateral channel. Section 8 details the calibration procedure, shows the model's validation test results, and reports the model predictions for the housing wealth and the firm collateral channel on employment. Finally, Section 9 concludes.

## 2 Why Property Taxes?

We begin the empirical portion of the paper by discussing the link between property tax changes and the housing wealth and firm collateral channel on employment.

Intuitively, property taxes are part of the costs of acquiring and holding real estate assets. Consequently, higher property taxes reduce the demand and price of real estate assets. While in the labor market, lower real estate prices decrease employment as labor demand reduces through the housing wealth or the firm collateral channel.

Now, consider the scenario of only an increase in property taxes for residential properties. In this case, The demand for employment should reduce due to the housing wealth effect because higher residential taxes lower the market price of this asset. In contrast, if only the tax rate for commercial properties increases, then the firm collateral channel should explain a decline in labor demand due to the negative impact of higher taxes on commercial real estate prices.

Therefore, an exogenous increase in the tax rate applied to residential and commercial properties should act as a specific shock, reducing the price of the real estate asset being taxed more heavily. Moreover, if the increase is different for each tax rate and is not correlated with the other tax rate, then we should have a way to separate both channels of interest affecting employment.

However, the estimates for the effect of higher property taxes on employment also capture other adjustments in the labor market. For example, changes in labor supply due to a wealth effect or adjustments in labor demand due to substitution between labor and commercial real estate.

The empirical analysis in this paper aims to provide a credible identification strategy to estimate the reduced form effect of higher property taxes on employment and other key variables for the housing wealth and firm collateral channel on labor. Moreover, the reduced form estimates provide crucial information that can be used in our model to quantify each channel affecting employment.

## 3 Institutional Background

In order to estimate the effect of higher property taxes on employment, consumption expenditure, and residential and real estate prices, we exploit the increase in property taxes during the 2012 tax reform in Italy. This section summarizes the main characteristics of the Italian property tax system and the tax reform that occurred in 2012.

The Italian territory is composed of approximately $8,000$ municipalities. Each municipality has a decentralized government defined by a Mayor and a local council. The functions of municipal governments are mainly related to providing local services such as education, public transportation, waste disposal, and social assistance. Municipal revenues come from property taxes, income tax surcharges, and transfers from the central government.

In 1992, Italian legislation created the "*Municipal tax on Properties*" or ICI.[2] According to the ICI system, each year local municipal authorities set two different property tax rates within a range determined by the general government. The *principal* tax rate applies to owners of residential properties used as a main dwelling. Meanwhile, the *secondary* tax rate is paid by owners of other types of properties, including commercial real estate.

The ICI system remained unchanged until April 2011, when the government led by Prime Minister Berlusconi announced the creation of the "Own Municipal Tax" or IMU[3] system, which was expected to replace the old ICI tax in January 2014.[4] Initially, the IMU system implied higher property tax rates but excluded the household's principal residence, already exempted from paying property taxes since March 2008.

However, the start of the Italian sovereign debt crisis led to the resignation of Prime Minister Berlusconi in November 2011. The newly appointed government led by Primer Minister Monti pushed forward an emergency fiscal package, named "*Save-Italy*" decree, to ease the pressure of financial markets on Italian sovereign debt. The "*Save-Italy*" decree relied on reforming the property tax system with the so-called "*Experimental*"-IMU. Contrary to the initial IMU system, the "*Experimental*"-IMU cancel the tax exemption on the main residence for household and raise the upper and lower thresholds for the *principal* and *secondary* tax rates. Moreover, the introduction date of the new "*Experimental*"-IMU was moved to January 2012.

The specific changes introduced by the "*Experimental*"-IMU required that: (*i*) municipalities set the property taxes within the range 0.2%-0.6% for the *principal* tax rate and

[2]From the Italian initials "*Imposta Comunale sugli Immobili*"

[3]From the Italian initials "*Imposta Municipale Unica*".

[4]See Article 8, paragraph 2, of Legislative Decree no. 23/2011.

0.46%-1.6% for the *secondary* tax rate,[5] (*ii*) tax rates had to be deliberated before October 31st (*iii*) the default rates of 0.4% for *principal* and 0.76% for *secondary* automatically applied if a municipality did not deliberate before the deadline (*iv*) municipalities needed to transfer back about 50% of the IMU tax revenues to the general government.

The fiscal adjustment measures significantly affected the central government's finances while only marginally raising the revenue of municipal governments. Meanwhile, the tax reform meant that owners of real estate assets had a higher tax burden. Figure 1 depicts the latter, with the solid blue and red line representing the average *principal* and *secondary* tax rate across municipalities, respectively. We observe that during 2012 the increase in property taxes was not only a unique event but also significant in magnitude. The average *principal* tax rate increased by 0.43 pp, while the average *secondary* tax rate increased by 0.15 pp. Except for 2012, the average rates remained constant even though municipalities could change property taxes during the entire 2008-2015 period.

Another salient feature of the 2012 tax reform is the observed variation in the tax rate changes across municipalities. Figure 2 shows a heat map for the Italian territory. The heat map on the left corresponds to the increase in *principal* tax rates, while the one on the right captures the increase in the *secondary* tax rate across municipalities. As we can see, the changes in property taxes during the 2012 property tax reform considerably varied across municipalities. The dispersion in *principal* and *secondary* tax rate changes across municipalities were significantly higher than in previous years. In particular, the standard deviation in tax rate changes observed in 2012 was about five times higher relative to 2011.

# 4 Data

We exploit the large increase in property taxes and the considerable variation in tax rate changes across municipalities to estimate the effect of higher property taxes on employment, consumption expenditure, and real estate prices. To that end, this section describes the details of constructing our novel municipal-level data.[6]

## 4.1 Property Tax Rates

The Institute for Finance and Local Economy (IFEL) provides data on property taxes. The IFEL is in charge of systematically collecting, processing and disseminating taxes-related data for local governments. The IFEL gathers data on property taxes from official acts issued by municipal governments regarding the adopted tax rates for a given year. The property tax data comprises the *principal* and *secondary* tax rates expressed in percentages

[5]The range for *principal* and *secondary* tax rates under ICI were 0.4%-0.7%, municipalities could set a deduction of up to 258.22 euros and a tax reduction of up to 50% only for properties used as the principal residence.

[6]The online appendix provides additional details about the construction of the data.

for all municipalities during 2004-2015. Therefore, we only keep municipalities created on or before 2004 with complete information on both property tax rates from 2008-2014.

## 4.2 Employment

Employment data come from the Annual Active Establishment Survey (ASIA) conducted by the Italian National Statistics Institute (ISTAT). In our data, employment captures the total number of employees working in active establishments within a municipality. Employment can be further disaggregated by economic sector using two-digit industry codes (NACE Rev. 2008, 2). We only keep industries in the private sector and exclude any construction-related industry.[7]

In our empirical strategy, we aim to estimate the effect of local property tax changes on local employment. However, employment in the tradable sector is sensitive to local policy shocks and demand shocks to other municipalities consuming tradable goods. Therefore, to capture local employment variation, we will only keep industries categorized as non-tradable.

To classify industries as tradable or non-tradable, we follow the dual approach in Mian and Sufi (2014). The first classification scheme employs aggregate sectoral world trade. We define a two-digit NACE sector as tradable if the aggregate industry ratio of total trade (*i.e.* exports plus imports) to gross production is higher than 0.16 or if the total trade per worker for that industry is larger than 56,000 euros.[8]

The second classification approach uses geographical concentration of employment across industries. Intuitively, industries producing tradable goods are spatially concentrated to take advantage of economies of scale. Instead, non-tradable industries are geographically dispersed in order to satisfy the local demand for non-tradable goods. To proxy concentration across sectors, we compute the Herfindahl index using industry shares of employment for each municipality. Then, we categorize the remaining industries not classified as tradable by the previous scheme. In particular, a two-digit NACE industry is tradable if the concentration index is above the $75^{th}$ percentile (0.026) and non-tradable if the concentration index is below the $50^{th}$ percentile (0.011).[9]

[7] This excludes industry codes 41-43 (Construction), 84-88 (Education, Health, Defense and Public Administration), and 97-99 (Activities of households as employers and extraterritorial organs and bodies). Furthermore, we exclude industry codes 01 (Agriculture, Fishing, and Forestry) and 05-09 (Mining and Quarrying) due to missing data problems

[8] The threshold values corresponded to the median across two-digit NACE industries in 2007.

[9] We employ two-digit industry municipal-level employment for 2007 to compute the concentration index. See the online appendix for the complete classification of tradable and non-tradable industries.

### 4.3 Real estate Prices

The Real Estate Market Observatory (OMI) is the main source of data on real estate prices. OMI divides each municipality into *homogeneous real estate markets*, which are areas with similar urban infrastructure, terrain, and socioeconomic characteristics. Using transaction data and surveys on real estate agents about local market conditions, OMI estimates a maximum and minimum value[10] per meter$^2$ for real estate properties in each homogeneous market within a municipality. The max and min values vary by property type (residential, commercial, production, and tertiary) and maintenance estate (excellent, average, and poor). Although the data is available on a semi-annual frequency for 2007-2014, we change the frequency to annual by keeping the second-semester value of each year.

We define residential and commercial real estate properties using the classification of property types in the data. In particular, residential properties comprise the categories *well-finished houses* and *economic dwelling houses*; both categories are the most prevalent residential property types along the Italian territory. On the other hand, for commercial real estate, we focus on property types used in the retail sector as this industry is considered the most representative of non-tradable economic activity (*e.g.* Mian and Sufi 2014, Guren et al. 2021). Specifically, we include *retail stores* and *shopping malls* as properties defining our category of commercial real estate. Lastly, we keep only residential and commercial real estate properties with average maintenance state.

Let $\overline{P}^k_{i(m),t}$, and $\underline{P}^k_{i(m),t}$ denote the max and min values of property type $k$ in homogeneous real estate market $i(m)$ within municipality $m$ and year $t$, respectively. Our analysis considers only residential and commercial real estate properties, then $k$ can be either houses ($h$) or commercial real estate ($f$). Finally, let $H_m$ represent the total number of homogeneous real estate markets within municipality $m$ in which an estimate for the min and max values of real estate type $k$ is available. Then, the real estate price measure for $k = \{h, f\}$, denoted $P^k_{m,t}$, is the average of $\overline{P}^k_{i(m),t}$ and $\underline{P}^k_{i(m),t}$ across all homogeneous real estate markets in municipality $m$.

$$P^k_{m,t} = \frac{1}{2}\left[\frac{1}{H_m}\sum_{i=1}^{H_m}\overline{P}^k_{i(m),t} + \frac{1}{H_m}\sum_{i=1}^{H_m}\underline{P}^k_{i(m),t}\right] \tag{1}$$

[10] The max and min estimates define the range of prices in which the average value of real estate units fall with the highest probability

## 4.4 Consumption Expenditure

There is no available data on consumption expenditure for Italy at the municipal level. To overcome this problem, we proxy household expenditures with a measure of new car purchases following a similar procedure as in Mian et al. (2013).

Let $X^{\text{cars}}_{m,t} = P^{\text{cars}}_{m,t}\, Q^{\text{Cars}}_{m,t}$ be the nominal household expenditure in car purchases for municipality $m$ at year $t$, where $P^{\text{Cars}}_{m,t}$ is the aggregate municipal price and $Q^{\text{Cars}}_{m,t}$ is the total number of new cars purchased by households in municipality $m$. Equivalently, we can define household expenditure in car purchases as $X^{\text{Cars}}_{m,t} = p^{\text{Cars}}_{m,t}\, \omega^{Q}_{m,t}\, X^{\text{Cars}}_{t}$, where $p^{\text{Cars}}_{m,t} = P^{\text{Cars}}_{m,t} / P^{\text{Cars}}_{t}$, $\omega^{Q}_{m,t} = Q^{\text{Cars}}_{m,t} / Q^{\text{Cars}}_{t}$, and $X^{\text{Cars}}_{t}$ are the relative price of cars, the share of cars purchased in a municipality, and the aggregate household expenditure in new vehicles, respectively.

Assuming that $p^{\text{Cars}}_{m,t} = p^{\text{Cars}}$, then changes in municipal-level expenditure on new vehicles are mainly captured by changes in the share of cars purchased in each municipality and by movements in aggregate household expenditure in new vehicles. Using the previous argument, we define our proxy measure $C^{\text{Cars}}_{m,t}$ as follows.

$$C^{\text{Cars}}_{m,t} = \widetilde{\omega}^{Q}_{m,t}\, X^{\text{Cars}}_{t} \tag{2}$$

where $\widetilde{\omega}^{Q}_{m,t}$ is computed with data on vehicle registrations provided by the Italian Automobile Club (ACI). In particular, equation (3) defines $\widetilde{\omega}^{Q}_{m,t}$ using the total number of first-time registrations for new *cars*[11] in each municipality during 2007-2014.

$$\widetilde{\omega}^{Q}_{m,t} = \frac{\text{New Cars Registered}_{m,t}}{\sum_m \text{ New Cars Registered}_{m,t}} \tag{3}$$

Notice that the aggregate our proxy measure (*i.e.* $\sum_m C^{\text{Cars}}_{m,t}$) is always consistent with the aggregate household expenditure on new vehicles from Italian national accounts. Finally, we deflate $C^{\text{Cars}}_{m,t}$ using the Consumer Price Index for Italy (100=2010).

## 4.5 Summary Statistics

Our balanced panel data contains information for 6,246 municipalities during 2008-2014. The selected sample is representative of the total universe of municipalities across the Italian territory. In particular, the number of municipalities in our sample represents 77% of the 8,092 municipalities in 2012. Furthermore, our selected sample captured 88%, 89.5%,

[11]The ACI data distinguish between nine different types of automobiles: *cars*, *buses*, *transportation trucks*, *vehicles for special use*, *motorcycles*, *quadricycles*, *transportation trailers*, *trailers for special use*, and *tractors*. *Cars*, are defined as any vehicle intended to transport persons with a maximum of nine seats, including the driver.

and 93% of the total population, employment, and income across the Italian territory in 2012.

Table 1 presents the summary statistics for 2012. In our data, the average municipality has an area of 59 square miles, a population of 8,278 residents, a real income per capita of 11,376 euros, and 2,193 persons are employed in private sector industries, out of which 41% are working in non-tradable industries.

Regarding property taxes, the average municipality raised the *principal* and *secondary* tax rates by 0.43% and 0.24%, respectively. For households owning residential properties, this meant an average payment of 322 euros in property taxes. At the same time, firms owning commercial real estate properties had to pay, on average, 200 euros more in property taxes.[12]

Moreover, our data for 2012 shows that, on average, employment in non-tradable industries increased by 2.5 %, while total employment and household expenditure on new vehicles dropped by 0.17 % and 5%, respectively. Finally, residential and commercial prices declined by 1.81% and 1.88%, respectively.

# 5 Empirical Strategy

This section describes the details of the empirical strategy. First, we present the diff-in-diff specification used in the empirical analysis. Next, we analyze the conditions under which our diff-in-diff estimator identifies the average treatment effect of higher property taxes on treated municipalities.

## 5.1 Parametric Specification

In our empirical analysis, property taxes are the main right-hand side variable. Let $\tau^h_{m,t}$ represent the *principal* tax rate and $\tau^f_{m,t}$ the *secondary* tax rate choose by municipality $m$ in year $t$. Then, the yearly tax rate change for $i = \{h, f\}$ is $\Delta\tau^i_{m,t} = \tau^i_{m,t} - \tau^i_{m,t-1}$.

Our treatment intensity variables are represented by $\Delta\tau^h_{m,2012}$ and $\Delta\tau^f_{m,2012}$. Both variables capture the exposure of each municipality to the 2012 property tax reform.

The main outcome variables of interest are non-tradable employment ($L$), consumption expenditure in new vehicles ($C$), residential prices ($P^h$), and commercial real estate prices ($P^f$). For outcome $Y = \{L, C, P^h, P^f\}$, let $y_{m,t}$ denote its symmetric growth defined in (4).

$$y_{m,t} = \frac{Y_{m,t} - Y_{m,t-1}}{(Y_{m,t} + Y_{m,t-1})/2} \tag{4}$$

[12] Property taxes in 2011 for firms owning commercial real estate properties was 1,270 euros for the average municipality.

We define our diff-in-diff baseline model in (5).

$$y_{m,t} = \text{FE}_m + \text{FE}_t + \beta_{y,h}\, \Delta\tau^{h}_{m,t} \times \mathbb{1}\{t=2012\} + \beta_{y,f}\, \Delta\tau^{f}_{m,t} \times \mathbb{1}\{t=2012\} + \epsilon_{m,t} \tag{5}$$

The two-way fixed effect (TWFE) specification in (5) control for fixed effects at the municipality ($\text{FE}_m$) and year level ($\text{FE}_t$). The inclusion of $\text{FE}_m$ and $\text{FE}_t$ in our model allows us to absorb any unobserved growth trend component that is municipality specific but constant over time or common across municipalities but change over time.

According to the literature (*e.g.* de Chaisemartin and D'Haultfœuille 2022 and Roth et al. 2022), the TWFE estimator is numerically equivalent to the canonical diff-in-diff model with two periods and a single binary treatment. Moreover, if the timing of the treatment is not staggered, the TWFE model can consistently identify the average treatment effect on the treatment under certain conditions.

The variable $\epsilon_{m,t}$ captures all the unobserved trend components of $y$. To provide asymptotically valid inference, we allow for correlation in the covariance matrix of $\epsilon_{m,t}$ across municipalities within the same local labor market. [13]

The main parameters of interest are $\beta_{y,h}$ and $\beta_{y,f}$. Each coefficient is associated with the interaction between the treatment intensity defined by the property tax rate change ($\Delta\tau^{i}_{m,t}$ for $i = \{h, f\}$) and a post-tax reform dummy ($\mathbb{1}\{t=2012\}$). The post-tax reform dummy takes the value of one only for 2012 because there are no significant changes in property taxes after the tax reform (see Figure 1).

## 5.2 Identification

Our empirical strategy aims to identify the average treatment effect of the 2012 property tax reform across municipalities with different treatment intensities. To define the conditions to achieve identification with the diff-in-diff strategy, we employ the potential outcome framework (Rubin, 1978).

To simplify the analysis, we assume municipalities have a single property tax rate $\tau_m$ that was increased at date $t_R$ due to an exogenously imposed property tax reform. Let $\widetilde{\Delta} = \{\Delta^1, \Delta^2, .., \Delta^L\}$ represent the set of possible tax rate increases, where $\Delta^{i-1} < \Delta^i$ for all $i = 1, .., L$. Additionally, assume that the difference between two consecutive tax increases is equal to one percentage point (*i.e.* $\Delta^i - \Delta^{i-1} = 1$).

Let $\left\{ (y_{m,t})_{t=1}^{T} \right\}_{m=1}^{M}$ denote our sample consisting of a balanced panel for outcome $y$ observed for $M$ municipalities during $T$ periods. Finally, assume $1 < t_R < T$.

[13] According to Mistrulli et al. (2019), local Labour markets (LLM) are "sub-regional geographical areas where the bulk of the labor force lives and works and where establishments can find most of the labor force necessary to occupy the offered jobs." To determine an LLM, ISTAT uses daily commuting flows recorded during the general population and housing censuses.

We denote the potential outcome function for variable $y$ as $y^i_{m,t}$. The potential outcome represents the value of $y$ for a municipality with a tax change $\Delta\tau_m \in \widetilde{\Delta}$ as if the tax increase were $\Delta^i$. Notice that, if $\Delta\tau_m \neq \Delta^i$ then $y^i_{m,t}$ captures the counterfactual value of $y$ under the alternative tax rate increase $\Delta^i$. On the contrary, if $\Delta\tau_m = \Delta^i$ then the potential outcome function is equivalent to the realized value observed in the data (*i.e.* $y_{m,t}$).

We are interested in estimating the average treatment effect on $y$ on municipalities affected by the tax reform. Equation (6) provides a formal definition of this moment, which we denote as $ATT^y_{t_R}$.

$$ATT^y_{t_R} = \mathbb{E}\left[ y^i_{m,t_R} - y^{i-1}_{m,t_R} \,\middle|\, \Delta\tau_m = \Delta^i \right] . \tag{6}$$

Notice that $ATT^y_{t_R}$ is not observable as it depends on the potential outcome function $y^{i-1}_{m,t}$, which is an unknown object to the econometrician.

On the other hand, equation (7) defines the diff-in diff estimator ($DiD^y_{t_R}$) for the property tax reform.

$$DID^y_{t_R} = \mathbb{E}\left[ y_{m,t_R} - y_{m,t_R-1} \,\middle|\, \Delta\tau_m = \Delta^i \right] - \mathbb{E}\left[ y_{m,t_R} - y_{m,t_R-1} \,\middle|\, \Delta\tau_m = \Delta^{i-1} \right] . \tag{7}$$

The main difference between $ATT^y_{t_R}$ and $DiD^y_{t_r}$ is that the latter is defined in terms of observable moments that can be estimated with the observed sample. However, if $y^i_{m,t}$ satisfy the *No Effect on the Pre-Treatment population* (*NEPT*) and the *Common Trend* (*CT*) conditions then $ATT^y_{t_R} = DiD^y_{t_R}$ (Lechner, 2011). Equations (8a) and (8b), formally define the *NEPT* and *CT* conditions.

$$\mathbb{E}\left[ y^j_{m,\widetilde{t}} \,\middle|\, \Delta\tau_m = \Delta^i \right] = \mathbb{E}\left[ y^i_{m,\widetilde{t}} \,\middle|\, \Delta\tau_m = \Delta^i \right] \tag{8a}$$

$$\mathbb{E}\left[ y^j_{m,t} - y^j_{m,t-1} \,\middle|\, \Delta\tau_m = \Delta^i \right] = \mathbb{E}\left[ y^j_{m,t} - y^j_{m,t-1} \,\middle|\, \Delta\tau_m = \Delta^j \right] , \tag{8b}$$

where $\Delta^j, \Delta^i \in \widetilde{\Delta}$ with $i < j$, and for $1 < \widetilde{t} < t_R$, and $1 < t < T$.

According to *NEPT* in equation (8a), conditional on a municipality choosing $\Delta^i$ before the tax reform, the outcome $y$ is not different from the counterfactual value under a lower tax increase $\Delta^j$. Intuitively, this condition states that municipalities do not anticipate the tax reform before the time it happens and therefore do not self-select into different tax treatment intensities.

On the other hand, the *CT* condition in (8b) implies that the trends in $y$ for municipalities choosing $\Delta^i$ but treated under a lower tax increase $\Delta^j$ should be parallel to the trends in $y$ for municipalities choosing and treated under the tax rate increase $\Delta^j$.

After reporting our baseline results in the next section, we discuss the credibility of our identification strategy in terms of the *NEPT* and *CT* conditions in more detail.

# 6 Estimation Results

This section reports the estimation results on non-tradable employment, consumption expenditure, and real estate prices. Initially, we present the results of the baseline specification. Next, we show the evidence providing credibility to our identification strategy in terms of the *NEPT* and *CT* conditions discussed in the previous section. Finally, we briefly discuss the robustness of the baseline results.

## 6.1 Baseline Estimation Results

Table 2 present our estimation results. The first and second rows show the estimates for $\beta_{y,h}$ and $\beta_{y,f}$, respectively. The third row computes the predicted interquartile range relative to the interquartile range in our data.[14]

At first glance, we can see that all the estimated coefficients in the first two rows are negative. Therefore, growth in non-tradable employment, consumption expenditure, and residential and commercial real estate prices reduce in municipalities with higher property taxes. However, we can also observe substantial disparities in magnitude and statistical significance when comparing the estimates for residential and commercial property taxes on each outcome,

For non-tradable employment growth, column ($\widehat{\beta}_{l,i}$), we see that, even though both estimates are statistically significant, the estimate for residential taxes almost doubles the estimate for commercial real estate taxes. Specifically, an additional percentage point increase in residential taxes reduces non-tradable employment growth by 0.087 pp. Conversely, the same increase in commercial real estate taxes produces a drop in non-tradable labor growth of 0.045 pp.

Similarly, for column ($\widehat{\beta}_{c,i}$), we find that consumption expenditure on new vehicles is three times more sensitive to changes in residential taxes than to commercial real estate taxes. Our results show that a one pp increase in residential taxes reduces consumption growth by 0.51 pp. In comparison, an equivalent increase in commercial real estate taxes is

[14] Specifically, this ratio is computed as follows:

$$\widehat{IQR}_y / IQR_{y,2012} = \frac{\widehat{\beta}_{y,h} \times \left( \Delta\tau^h_{\mathrm{P}^{75},2012} - \Delta\tau^h_{\mathrm{P}^{25},2012} \right) + \widehat{\beta}_{y,f} \times \left( \Delta\tau^f_{\mathrm{P}^{75},2012} - \Delta\tau^f_{\mathrm{P}^{25},2012} \right)}{y_{\mathrm{P}^{25},2012} - y_{\mathrm{P}^{75},2012}}$$

Where $\Delta\tau^i_{\mathrm{P}^{25},2012}$ and $\Delta\tau^i_{\mathrm{P}^{75},2012}$ are the first and third quartiles of the tax rate change for $i = \{h, f\}$ in 2012. Similarly, $y_{\mathrm{P}^{25},2012}$ and $y_{\mathrm{P}^{75},2012}$ are the first and third quartiles of the growth rate for outcome $Y = \left\{L, C, P^h, P^f\right\}$ in 2012.

associated with a non-statistically significant drop of 0.177 pp for consumption expenditure growth.

The results for consumption are similar to previous findings (*e.g.* Surico and Trezzi 2019) and are consistent with heterogeneity in the marginal propensity to consume relative to household wealth. Intuitively, single-house owners only pay the *principal* tax rate (*i.e.* residential taxes), while wealthier multiple-house owners also pay the *secondary* tax rate (*i.e.* commercial taxes). Therefore, the higher response of consumption expenditure to higher residential taxes captures the high marginal propensity to consume of single-house owners that are more likely to be financially constrained. Conversely, the relatively small response of consumption expenditure to higher commercial taxes is consistent with a low marginal propensity to consume for wealthy households less affected by financial constraints.

Likewise, columns ($\widehat{\beta}_{p^h,i}$) and ($\widehat{\beta}_{p^f,i}$) show that that the response of real estate prices to its own tax rate is relatively higher than the response to the other tax rate. In this case, a one pp higher increase in residential taxes reduces housing price growth by 0.02 pp but does not seem to affect the price of commercial real estate properties. At the same time, a one pp increase in the tax rate for commercial real estate properties reduces its price growth by 0.032 pp, while its effect on the residential price growth is approximately half (0.017 pp).

Additionally, notice that the estimate for commercial prices to changes in residential taxes is not statistically significant. This result is consistent with our definition of commercial real estate, which includes properties that cannot be used for residential purposes. On the contrary, the significant response of residential prices to changes in commercial taxes should capture the response of households owning multiple residential properties. Nonetheless, higher commercial taxes have a lower impact on residential prices than on commercial real estate prices, which could result from multiple-house owners having a less sensitive demand for residential properties.

Finally, regarding economic significance, our diff-in-diff estimates seem to capture a significant portion of the empirical interquartile range for each outcome variable of interest. In particular, our baseline estimates capture 20%, 17%, 12%, and 7% of the interquartile range for non-tradable employment, commercial real estate prices, residential prices, and consumption expenditure, respectively.

## 6.2 Anticipation of the 2012 Property Tax Reform

As we described before, the *NEPT* condition is necessary for identification with our diff-in-diff strategy. We recognize two main scenarios that could create issues with this condition: *(i)* if municipalities anticipate the tax reform, *(ii)* if municipalities have gone through a significant tax change in the past. However, as we discuss next, the characteristics of the tax reform and property tax system in Italy make *(i)* and *(ii)* unlikely.

On the one hand, the timing and intensity of the tax increase imposed by the *Experimental*-IMU were difficult to anticipate. The reason is that the announcement about the IMU system in April 2011 should have cemented people's expectations about the future property tax increase. However, at the end of 2011, the central government changed its initial intentions by announcing a *Experimental*-IMU scheduled to start in January of 2012, with the latter increasing the *principal* and *secondary* tax rate in a larger magnitude. Therefore, it should have been difficult, if not impossible, for the general population and local governments to anticipate the *Experimental*-IMU tax applied in 2012.

On the other hand, there is still the issue of past property tax changes and their lag effect on the outcomes of interest. First, correlation in property tax changes across time means municipalities self-select into treatment intensity groups during the 2012 tax reform. Second, if past changes in property taxes have a long-lasting impact on municipal-level outcomes, then a confounding factor would contaminate the outcome's response during the 2012 tax reform. In either case, the diff-in-diff estimator would be biased. However, the latter issues are unimportant for our particular empirical strategy. The main reason is that property tax rates across Italian municipalities stayed predominantly constant from year to year. As shown in Figure 1, local authorities are reluctant to change property tax rates unless forced by the central government during tax reforms. In other words, property tax rates are persistent and uncorrelated to local economic fluctuations.

## 6.3 Parallel Trends and the 2012 Tax Reform

The second condition necessary for identification is the *CT* condition. However, testing for parallel trends requires knowledge about the potential outcome function, which is unknown to the econometrician. Nevertheless, the diff-in-diff literature employs the event study approach as a feasible alternative to test for parallel trends. In what follows, we discuss its implementation and the results obtained for the 2012 tax reform in Italy.

### 6.3.1 Event-Study Approach: Implementation

The idea of the event study approach is to use pre-reform data to estimate the lead effects of the treatment variable. The lead effects should capture differences in outcome trends across treatment intensity groups before the tax reform. Therefore, if the parallel trend condition is not satisfied, we should observe significant disparities in outcome trends before the 2012 tax reform.

The implementation of the event study analysis for the 2012 tax reform in Italy follows the specification in (9).

$$y_{m,t} = \text{FE}_m + \text{FE}_t + \sum_{\tilde{t} \neq 2011} \beta_{y,h}^{\tilde{t}} \, \mathbb{1}\{t = \tilde{t}\} \times \Delta\tau_{m,2012}^{h} + \sum_{\tilde{t} \neq 2011} \beta_{y,f}^{\tilde{t}} \, \mathbb{1}\{t = \tilde{t}\} \times \Delta\tau_{m,2012}^{f} + \epsilon_{m,t} \tag{9}$$

Differently to our baseline model in (5), the specification (9) include leading and lagged values of our treatment intensity variables (*i.e.* $\Delta\tau_{m,2012}^{h}$ and $\Delta\tau_{m,2012}^{f}$). The lagged coefficients $\beta_{y,h}^{t^+}$ and $\beta_{y,f}^{t^+}$ for $t^+ = \{2013, 2014\}$ capture the effects of the increase in property taxes $T^+$ years after the tax reform, for $T^+ = t^+ - 2012$. At the same time, $\beta_{y,h}^{2012}$ and $\beta_{y,f}^{2012}$ represent the immediate effect of the 2012 tax reform.

We are particularly interested on the lead coefficients $\beta_{y,h}^{t^-}, \beta_{y,f}^{t^-}$, for $t^- = \{2008, 2009, 2010\}$, with 2011 as our base year. To test for parallel trends we check the composite null $\beta_{y,i}^{2008} = \beta_{y,i}^{2009} = \beta_{y,i}^{2010} = 0$. Any statistically sizable correlation between past trends in $y$ and the tax increase during the 2012 tax reform in Italy will make rejecting our null more likely.

#### 6.3.2 Event-Study Approach: Results

Figure 3 and Figure 4 depict the results of event study analysis for residential and commercial taxes, respectively. In each figure, the blue dots line represents the point estimates and the red dashed lines the 95% confidence interval. The estimates for the lead effects are located to the left of the black vertical dashed line, while the contemporaneous and lag estimates are to the right of this line.

Notice that the lead estimates for residential and commercial taxes are not statistically significantly different from zero for each outcome variable. As a result, we do not reject the null hypothesis of no pre-trend differences across municipalities with different tax rate changes. Therefore, we found no evidence that municipalities choosing relatively higher tax rate changes in 2012 had differential growth trends for non-tradable employment, consumption expenditure, and real estate prices before 2012.

The absence of systematic trend differences is consistent with Alesina and Paradisi (2017). They find that the staggered timing of local elections primarily explains the size of the property tax increase across municipalities during the 2012 tax reform. Moreover, given that the timing of local elections was defined in the late 1940s, they conclude that election timing across Italian municipalities is as good as a random assignment.

Therefore, under the premise that political factors unrelated to business cycle fluctuations determine the property tax change across municipalities, it becomes clear that the lack of evidence for systematic trend differences reflects the intrinsic characteristics of the property tax system in Italy.

Another result we discuss is the null effect of the tax increase after the tax reform. We can see that the lag estimates for 2013 and 2014 are not statistically significant at the 5% confidence level. The latter means that we only observe an outcome response during the year of the tax reform with no significant effect in the following years. Two potential explanations can be used to understand the previous result.

On the one hand, residents of Italian municipalities could have internalized that changes in property taxes happen only during tax reforms. Therefore, the probability of future tax reforms is relevant to set expectations about future property tax changes. According to the 2012 Italian Survey on Household Income and Wealth (*SHIW*), households only assigned a 33% probability of having a new tax reform within the next five years, meaning that they believed that there was a 67% chance of not having additional changes to property taxes in the future.[15] We can interpret the previous evidence as an indication that households considered the 2012 change in property taxes as permanent. This should explain the significant response of municipal outcomes observed during the year of the property tax reform.

On the other hand, as we mentioned on section 3, the unpopularity of the 2012 property tax reform forced the central government to cancel the "*Experimental*"-IMU tax after just one year, which explains why the increase in property taxes during the 2012 tax reform had no statistically significant effect after 2012.

### 6.4 Additional Robustness Checks

To conclude the empirical portion of the paper, we briefly describe the findings of additional tests and robustness checks we perform to strengthen the credibility of the baseline results. A more detailed discussion is available in the online appendix.

First, following (Imbens and Rubin, 2015), we perform a covariate balance analysis to check for potential unbalances in observable characteristics across municipalities. Our results show that municipalities with different property tax rate changes are similar in terms of economic and financial local conditions, migration patterns, and industry employment shares. Additionally, the evidence suggests that local governments that raised property taxes more had higher revenue growth, lower deficit, and were less

[15]We base this evidence on the response to the 2012 questionnaire which in question **D37** ask: "*In your opinion, which is the probability that the Municipal Property Tax (IMU) will be abolished within the next five years and not replaced by another similar tax? On a scale of 0 to 100, assign a low number if there is little chance of this happening and a high one if there is a good chance.*"

indebted. Nevertheless, they were similar in terms of expenditure growth and investment rate.

Additionally, we test the robustness of the baseline results by changing the specification in several ways: (*ii*) including municipal-level covariates to control for pre-tax reform differences across municipalities. (*ii*) including interactions between the treatment intensities and variables meant to capture alternative channels that could explain our baseline results, and (*ii*) including controls for spillover effects.

Overall, our baseline results are robust in magnitude and statistical significance. In most cases, the point estimates remain negative and relatively close to the baseline results.

# 7 Model

In this section, we develop a general equilibrium model representing the average municipality. The model provides the framework to quantify the housing wealth and firm collateral channel on employment induced by a property tax increase.

Our economy lasts one period and comprises households, firms, and a construction sector. Firms produce non-tradable differentiated goods using labor and commercial real estate. Households supply labor, consume an aggregate basket of differentiated goods, and purchase residential properties. The construction sector produces residential and commercial real estate properties.

Households and firms can get loans from the foreign financial market. Loans are paid within the period, charge zero interest, and require real estate collateral (*i.e.* residential or commercial real estate properties). Consequently, the value of real estate assets owned by households and firms determines the maximum loan they can obtain.

Lastly, the government exogenously sets a differential property tax rate for real estate assets. Specifically, let $\tau^h$ and $\tau^f$ represent the tax rate applied to residential and commercial real estate owners, respectively.

This section starts by presenting the problem of households and firms. Then we provide an analytical solution for the competitive equilibrium and find the model's predictions of higher property taxes. As we show later, our model allows us to isolate the part of the employment response explained by either the housing wealth or firm collateral channel.

## 7.1 Household Problem

The representative household's problem is divided into two stages. In a first stage, households determine their labor supply ($L$) and expenditure on housing ($H^h$) and non-housing goods ($C$). The first stage problem is as follows.

$$\underset{\{C,L_s,H^h\}}{\text{maximize}} \quad (C)^{\beta}(H^h)^{1-\beta} - \frac{\chi}{1+\frac{1}{\nu}}L^{1+\frac{1}{\nu}}$$

$$\text{subject to} \quad C + P^h H^h \left(1+\tau^h\right) = W L + \Pi \tag{10a}$$

$$C \leq \phi_h \, P^h H^h \;\; (\mu^h) \tag{10b}$$

Household preferences for consumption and leisure are separable, implying that the labor supply responds to household wealth changes. The aggregator for housing services and non-housing goods is Cobb-Douglass. We assume that $H^h$ is a continuous variable, and the representative household does not own an initial endowment of residential properties.

Equation (10a) capture the budget constraint. Household income comes from wages ($WL$) and aggregate profits ($\Pi$). Total income is allocated on consumption expenditure ($C$), housing expenditure ($P^h H^h$) and property taxes ($P^h H^h \tau^h$). The consumption good will be the numeraire for the economy (*i.e.* $P_c = 1$).

Equation (10b) represent the borrowing constraint for households. The shadow value of the borrowing constraint is denoted by $\mu^h$. The implicit assumption of (10b) is that consumption expenditure is paid with loans requiring collateral in the form of residential assets. In particular, $\phi_h$ denotes the collateral requirement for households.

In the second stage, the representative household decides the optimal allocation of total expenditure on non-housing on each variety ($c_j$). We assume that a CES-aggregator combines all varieties into the final consumption good.

The second stage problem is outlined next.

$$\underset{c_j}{\text{minimize}} \quad \int_0^1 p_j c_j dj \tag{11a}$$

$$\text{subject to} \quad C \geq \left( \int_0^1 c_j^{1-\frac{1}{\epsilon}} \, dj \right)^{\frac{1}{1-\frac{1}{\epsilon}}} \tag{11b}$$

## 7.2 Firm Problem

Each variety $j \in [0,1]$ is produced by a monopolistically competitive firm using labor ($L$) and commercial real estate assets ($H^f$). Given the market structure, each firm sets prices above the marginal cost. The profit maximization problem for the firm producing variety $j$ is outlined next.

$$\underset{\{L,H^f\}}{\text{maximize}} \quad p_j c_j - W L_j - P^f H_j^f \left(1 + \tau^f\right) \tag{12a}$$

$$\text{subject to} \quad p\left(c_j\right) = \left(\frac{C}{c_j}\right)^{\frac{1}{\epsilon}} \tag{12b}$$

$$c_j = F(L_j, H_j^f) = \left(L_j\right)^{\alpha} \left(H_j^f\right)^{1-\alpha} \tag{12c}$$

$$W L_j \leq \phi_f P^f H_j^f \quad (\mu^f) \tag{12d}$$

Equation (12b) is the optimal inverse demand function for variety $j$ obtained from the second stage problem of households. At the same time, equation (12c) represents the firm's constant return of scale production function. In addition to labor costs and real estate investment, firms need to pay $P^f \ H_j^f \ \tau^f$ as property taxes for owning commercial real estate.

Finally, firms use loans to finance working capital requirements for labor. Similarly to households, firms must provide guarantees in the form of real estate assets. In particular, firms pledge a fraction $\phi_f$ of the commercial real estate assets value. Equation (12d) captures the collateral constraints for firms, and $\mu^f$ denotes its shadow value.

## 7.3 Residential and Commercial Real Estate Supply

The last private agent in our economy is the construction sector. To simplify our analysis, we assume that (13a) and (13b) are the supply functions for residential and commercial real estate properties, respectively.

$$H^h(P^h) = (P^h)^{\sigma_h} \tag{13a}$$

$$H^f(P^f) = (P^f)^{\sigma_f} \tag{13b}$$

The parameters $\sigma_h$ and $\sigma_f$ capture the price supply elasticities for residential and commercial properties, respectively.

The reduced-form approach to modeling the construction sector has three main implications, which we discuss next.

First, equations (13a) and (13b) imply that the construction sector only uses land to produce properties but not labor. This assumption is consistent with our definition of non-tradable municipal-level employment in the empirical section, which excludes any construction-related industry.[16]

[16] See subsection 4.2.

The second implication is that there is no land competition between real state developers building residential and commercial properties. The lack of competition between developers could result from government-imposed zoning laws on land use.[17] As a consequence, changes in real estate prices do not induce employment fluctuations due to a land reallocation channel as in Liu et al. (2013).

Finally, changes in property taxes do not impact the construction sector in our model. This assumption is consistent with the Italian property tax system and the changes introduced during the 2012 tax reform. In particular, with the *Experimental*-IMU, unsold properties registered in the Italian cadastral system initially experienced a tax rate drop from 0.40% to 0.38% and by 2013, taxes were completely exempted for real estate designated for sale (*i.e.* owned by real estate developers). Therefore, property taxes on unsold properties owned by the construction sector did not increase in the same magnitude as taxes for properties owned by households or firms.

### 7.4 Constrained Competitive Equilibrium

In equilibrium, the markets for goods, labor, and real estate properties clear. The equilibrium prices and allocations are consistent with the optimization problems for households and firms and the supply of residential and commercial real estate properties. Definition 1 formally defines the competitive equilibrium in our model.

**Definition 1** (Competitive Equilibrium): *A competitive equilibrium consists of a set of prices* $\left\{W, P^h, P^f, (p_j)_{j\in[0,1]}\right\}$, *allocations* $\left\{L, H^h, H^f, C, \ (c_j)_{j\in[0,1]}\right\}$, *shadow values* $\left\{\mu^h, \mu^f\right\}$, *and property tax rates* $\left\{\tau^h, \tau^f\right\}$ *such that:*

1. *Given equilibrium prices* $\left\{W, P^h, P^f, (p_j)_{j\in[0,1]}\right\}$ *and property tax rates* $\left\{\tau^h, \tau^f\right\}$
   (a) *Household choices for* $L$, $H^h$ *and* $C$ *solve* (10) *with* $\mu^h \geq 0$ *and* $(c_j)_{j\in[0,1]}$ *solve* (11).
   (b) *Firm choices for* $L$ *and* $H^f$ *solve* (12) *with* $\mu^f \geq 0$.
   (c) *supply of houses and commercial real estate is consistent with* (13b) *and* (13a), *respectively.*
2. *Given the allocation* $\left\{L, H^h, H^f\right\}$ *and property tax rates* $\left\{\tau^h, \tau^f\right\}$
   (a) $W$ *is the wage that clear the labor market*
   (b) $\left\{P^h, P^f\right\}$ *are the real estate prices that clear the markets for residential and commercial properties, respectively.*

[17] For Italy, each municipality divides its territory into zones in which properties for specific use (*e.g.* residential or commercial) can be built.

From now on, we assume that the collateral constraints for households and firms bind in equilibrium.[18]

We now move to characterize the constrained competitive equilibrium in our economy. The fully static nature of our model has two advantages. First, the analytical solution for the model's equilibrium allows us to compute the response of employment, consumption, and real estate prices to higher property taxes that maps one-to-one with our diff-in-diff estimates. Second, the linear decomposition of the labor's response to higher property taxes allows us to separate each channel of interest from additional mechanisms affecting the labor market.

In particular, Proposition 1 shows that the analytical solution for equilibrium employment, consumption expenditure, and real estate prices in our model is approximately log-linear in property taxes.

**Proposition 1** (Log-linear Equilibrium): *Let $\Theta = [\alpha, \beta, \nu, \epsilon, \sigma_f, \sigma_h, \phi_h, \phi_f]$ represent the structural parameters in the model. If $\frac{\tau^h}{1+\phi_h}$, $\frac{\tau^f}{1+\phi_f}$ and $\frac{\tau^f}{1+\epsilon\phi_f}$ are small enough, then the $L$, $C$, $P_h$, and $P_f$ in equilibrium are log-linear in $\tau^h$ and $\tau^f$.*

There are two implications we draw from Proposition 1. First, using the log-linear equilibrium for $L$, $C$, $P_h$, and $P_f$, we can compute the reduced-form effect of a change in property taxes in our model. Second, using the reduced-form effect of labor, we can isolate the part explained by the housing wealth and firm collateral channel. We formally address both implications in the next part of the paper.

## 7.5 Property Tax Changes and Equilibrium Response

Consider a property tax reform characterized by a rise in the tax rates from $(\tau^{h,\text{low}}, \tau^{f,\text{low}})$ to $(\tau^{h,\text{HIGH}}, \tau^{f,\text{HIGH}})$; where $\tau^{i,\text{HIGH}} > \tau^{i,\text{low}}$, for $i = \{h, f\}$. Furthermore, let $Y^k$ denoted the constrained equilibrium of $Y = \left\{P^h, P^f, L, C\right\}$ under property tax scheme $k = \{\text{HIGH}, \text{low}\}$. The effect of the property tax increase is captured by $y = \log\left(Y^{\text{HIGH}}\right) - \log\left(Y^{\text{low}}\right)$. Notice that the log-linear nature of the constrained equilibrium in our model implies that $y$ is a linear function of the tax change for residential and commercial properties. The latter result is presented in Proposition 2.

**Proposition 2** (Model's Reduced Form Coefficients): *For a fixed value of $\Theta$, let $(\tau^{h,k}, \tau^{f,k})$ be a the property tax rates for tax scheme $k = \{\text{HIGH}, \text{low}\}$. Then, the equilibrium response of $Y = \left\{P^h, P^f, L, C\right\}$ due to an increase in property taxes equal to $(\Delta\tau^h, \Delta\tau^f)$, can be characterized*

[18]The online appendix describes in detail the necessary and sufficient conditions that guarantee both collateral constraints binding in equilibrium.

*as follows:*

$$y \;=\; \beta_{y,h}(\Theta)\,\Delta\tau^{h} \;+\; \beta_{y,f}(\Theta)\,\Delta\tau^{f} \tag{14}$$

*where* $\Delta\tau^{i} = \tau^{i,HIGH} - \tau^{i,low}$ *is the the percentage point tax increase for tax rate* $i = \{h, f\}$ *and* $y = \log(Y^{HIGH}) - \log(Y^{low})$ *is the percentage point change in* $Y$*. At the same time,* $\beta_{y,i}(\Theta)$ *represent the model-implied reduced-form effect on variable* $Y$ *due to a change in the i-tax rate equal to* $\Delta\tau^{i}$*.*

Notice that the model-implied linear mapping in (14) is similar to the parametric specification (5) estimated in the empirical section. According to Proposition 2, the model's reduced-form effects (*i.e.* $\beta_{y,i}(\Theta)$) depend on the structural parameters and, consequently, are invariant to policy changes. Therefore, if our empirical strategy correctly identifies the reduced-form effect of higher property taxes, we can use the estimations obtained with Italian municipal data to discipline the model.

## 7.6 The Housing Wealth and Firm Collateral Effect from a Property Tax Change

The predictions of the model regarding the reduced form coefficients for employment (*i.e.* $\beta_{l,h}(\Theta)$, $\beta_{l,f}(\Theta)$) are of particular interest in our case. The reason is that they capture the two channels of interest on employment after a property tax increase. Before describing how we separate each channel from the total employment response predicted by the model, we formally define the housing wealth and firm collateral channel from a property tax change.

**Definition 2** (Housing Wealth and Firm Collateral Channel): *Let* $\Delta\tau^{h} > 0$, $\Delta\tau^{f} = 0$, *and* $p^{f} = 0$. *Then the housing wealth channel on employment* ($\delta^{wealth}$) *is the response of labor demand to an adjustment of consumption expenditure after a change in residential prices induced by a marginal change in* $\Delta\tau^{h}$*. The latter is formally defined as follows:*

$$\delta^{wealth} = \frac{\partial l}{\partial \Delta\tau^{h}} = \frac{\partial l^{d}}{\partial c}\frac{\partial c}{\partial p^{h}}\frac{\partial p^{h}}{\partial \Delta\tau^{h}} \tag{15}$$

*Equivalently, let* $\Delta\tau^{f} > 0$, $\Delta\tau^{h} = 0$, *and* $p^{h} = 0$. *Then, the firm collateral channel on employment* ($\delta^{coll}$) *is the response of labor demand to changes in commercial real estate prices induced by an infinitesimal change in* $\Delta\tau^{f}$*. The formal definition can be found next:*

$$\delta^{coll} = \frac{\partial l}{\partial \Delta\tau^{f}} = \frac{\partial l^{d}}{\partial p^{f}}\frac{\partial p^{f}}{\partial \Delta\tau^{f}} \tag{16}$$

*where $l^d = \log L^{d,HIGH} - \log L^{d,low}$ is the log-percentage response of labor demand $L^d$ to the change in property tax schemes.*

According to Definition 2, higher residential property taxes—keeping commercial real estate taxes constant—should induce a response of employment through the housing wealth channel. Likewise, an increase in commercial real estate taxes—leaving residential property taxes unchanged—produces an employment adjustment through the firm collateral channel. Notice that in Definition 2, $\delta^{\text{wealth}}$ and $\delta^{\text{coll}}$ captures a partial equilibrium change in labor demand after the price of the real estate asset being taxed more heavily adjusts.

There are additional insights that Definition 2 provide about the internal workings of each channel. On the one hand, (15) shows that the housing wealth channel captures an *indirect* change in labor demand caused by lower household expenditure in final goods due to a drop in residential prices after the increase in property taxes. On the other hand, the firm collateral channel captures the *direct* response of employment demand due to the lower firm's collateral value resulting from a decline in commercial real estate prices after the increase in property taxes.

We can further characterize $\delta^{\text{wealth}}$ and $\delta^{\text{coll}}$, by applying Definition 2 to the firms' optimal labor demand. As a result, we obtain equations (18) and (17) that show the relationship between each channel and the structural parameters in the model.[19]

$$\delta^{\text{wealth}}(\Theta) = -\left[\frac{1}{1+\phi_h}\right]\left[\frac{(1+\sigma_h)(1+\alpha(\epsilon-1))(1+\nu)\nu}{(1+\sigma_h+\nu(1-\beta))(1+\nu+\alpha(\epsilon-1))\alpha(\epsilon-1)}\right] \tag{17}$$

$$\delta^{\text{coll}}(\Theta) = -\left[\frac{1}{1+\phi_f}\right]\left[\frac{(1+\sigma_f)\nu\epsilon}{(1+\sigma_f)(1+\nu+\alpha(\epsilon-1))+(1+\nu)(1-\alpha)(\epsilon-1)}\right] \tag{18}$$

Notice that, as initially expected, $\delta^{\text{wealth}}(\Theta)$ and $\delta^{\text{coll}}(\Theta)$ are negative, for any value of $\Theta$. Therefore, our model predicts an employment drop after higher property taxes due to the effect of the housing wealth or the firm collateral channel on labor demand.

Two sets of structural parameters determine the magnitude of the decline explained by each channel: (*i*) the price supply elasticities for real estate and (*ii*) the collateral requirements for households and firms.

On the one hand, differences in the supply elasticity for residential ($\sigma_h$) and commercial ($\sigma_f$) properties should affect the relative importance of each channel on employment.

[19]We provide a formal proof of this result in the mathematical appendix, available online.

Intuitively, a relatively more inelastic housing (commercial real estate) supply translates into a more significant decline in residential (commercial) prices after higher property taxes. Therefore, the housing wealth (firm collateral) channel should gain importance on employment decline because residential (commercial) prices drop more due to higher property taxes.

On the other hand, differences in collateral requirements for residential and commercial real estate assets defined by the loan-to-value ratio for households ($\phi_h$) and firms ($\phi_f$) should also affect the importance of each channel on employment. Intuitively, higher collateral requirements for households (*i.e.* lower $\phi_h$) mean that borrowing constraints bind more for households, so a drop in residential prices reduces consumption expenditure by more. The latter makes the housing wealth channel more important in explaining the employment decline. In comparison, higher collateral requirements for firms (*i.e.* lower $\phi_f$) increase the importance of the firm collateral channel because the sensitivity of labor demand to changes in the firm's collateral value increases.

We move to describe the main result of the model. Specifically, we decompose $\beta_{l,h}(\Theta)$ and $\beta_{l,f}(\Theta)$ into two parts, a first part capturing the two channels of interest (*i.e.* $\delta^{\text{wealth}}(\Theta)$ and $\delta^{\text{coll}}(\Theta)$) and a second part encapsulating all other effects present when property taxes increase, we present this decomposition in Proposition 3.

**Proposition 3** (Decomposing the Employment Response): *Coefficients $\beta_{l,h}(\Theta)$ and $\beta_{l,f}(\Theta)$ can be decompose as follows:*

$$\begin{aligned}\beta_{l,h}(\Theta) = \quad & \delta^{wealth}(\Theta) - \frac{\nu + \alpha(\epsilon-1)}{1+\nu+\alpha(\epsilon-1)}\left[\frac{\nu}{1+\phi_h} + (1-\beta)\nu\,\beta_{p^h,h}(\Theta)\right] \\ & - \frac{\nu(1-\alpha)}{1+\nu+\alpha(\epsilon-1)}\left[\frac{(1+\nu)(1+\sigma_h)}{\alpha A_h} + (\epsilon-1)\right]\beta_{p^f,h}(\Theta)\end{aligned} \tag{19a}$$

$$\begin{aligned}\beta_{l,f}(\Theta) = \quad & \delta^{coll}(\Theta) - \frac{(1-\beta)\nu}{1+\nu}\left[1 + \frac{\alpha(\epsilon-1)(1+\sigma_f)}{A_f}\right]\beta_{p^h,f}(\Theta) \\ & + \left[\frac{(1+\sigma_f)(1+\sigma_h)\nu}{A_f}\right]\beta_{p^h,f}(\Theta)\end{aligned} \tag{19b}$$

*where:* $A_f = (1+\sigma_f)(1+\nu+\alpha(\epsilon-1)) + (1+\nu)(1-\alpha)(\epsilon-1)$, $A_h = 1+\sigma_h+(1-\beta)\nu$ $\delta^{wealth}(\Theta)$ *and* $\delta^{coll}(\Theta)$ *are defined in (17) and (18), respectively.*

The decomposition result in Proposition 3 has an intuitive interpretation, which we depict in Figure 5 and Figure 6. Specifically, the decomposition in (19a) is represented in Figure 5, while the interpretation of equation (19b) is shown in Figure 6.

An increase in residential taxes by $\Delta\tau^h = \tau_1^h - \tau_0^h$ shifts the housing demand to the left, reducing prices and housing units sold in the residential market (Figure 5a). The drop in housing wealth reduces the collateral value for residential assets. The tightening of the borrowing constraints for households results in lower consumption expenditure in non-housing goods from $C\left(P^h(\tau_0^h)\right)$ to $C\left(P^h(\tau_1^h)\right)$. In the labor market, Figure 5b shows that firms producing varieties respond to the drop in household consumption by shifting the demand for labor from $L^d\left(P_0^f, C(P_0^h)\right)$ to $L^d\left(P_0^f, C(P^h(\tau_0^h))\right)$. The drop in labor represents the housing wealth channel on employment ($\delta^{\text{wealth}} = L_B - L_0$).

Similarly, an increase in commercial real estate taxes by $\Delta\tau^f = \tau_1^f - \tau_0^f$, produces a left-hand shift in the demand for commercial estate assets. Figure 6a shows that the equilibrium in the commercial real estate market moves from $\left\{P^f(\tau_0^f), H_0^f\right\}$ to $\left\{P^f(\tau_1^f), H_B^f\right\}$. As a result, the collateral value of commercial real estate assets reduces, firms' financial constraints bind even more, and firms respond by lowering the labor demand. from $L^d\left(P^f(\tau_0^f, C(P_0^h)\right)$ to $L^d\left(P^f(\tau_1^f), C(P_0^h)\right)$. The drop in employment depicted in Figure 6b captures the firm collateral channel on employment induced by higher commercial real estate taxes ($\delta^{\text{coll}} = L_B - L_0$).

The remaining terms in (19a) and (19b), represent the labor adjustment due to a general equilibrium effect. In particular, two mechanisms capture the remaining part of employment adjustment due to higher property taxes.

On the one hand, residential prices induce labor supply changes through a wealth effect in our model. The latter implies that higher residential taxes reduce residential property value and increase the labor supply due to a wealth effect. The case is similar if commercial taxes increase instead. In this scenario, a decrease in aggregate profits reduces households' wealth and the demand for housing services, resulting in a drop in residential prices and an adjustment of labor supply. Figure 5c and Figure 6c provide a visual depiction of the labor supply shift due to lower residential prices induced by higher property taxes. In the previous depiction, employment increases by $L^C - L^B$, partially reverting the decline in labor due to the housing wealth and firm collateral channel, respectively. In terms of Proposition 3, the middle terms of equations (19a) and (19b) capture these supply adjustments of employment.

We need to make an additional note on the effect of property taxes on labor supply. In our model, higher residential taxes lower the budget constraint's shadow value relative to the shadow value of the household's borrowing constraint. Consequently, households are forced to reduce labor supply to lower the value of the marginal rate of substitution between labor-non-housing goods.[20] Therefore, there are two opposite effects on labor

[20]This effect is captured by $\frac{\nu}{1+\phi_h}$ in the middle term of decomposition (19a).

supply when residential taxes increase: (*i*) an *indirect wealth effect* increase labor supply because residential property prices reduce, (*ii*) a *direct effect* on the intratemporal condition for optimal labor which reduces labor supply due to a drop in the shadow value of budget constraint. In contrast, higher commercial real estate taxes only produce a labor supply response through (*i*).

On the other hand, higher property taxes trigger additional changes in labor demand. In the case of higher residential taxes, the negative effect on commercial real estate prices induces an increase in labor demand due to lower marginal costs and higher consumption expenditure. On the contrary, an increase in commercial real estate taxes reduces labor demand as consumption expenditure drops due to the negative effect of commercial taxes on aggregate profits and household wealth. The additional changes in labor demand are depicted Figure 5d and Figure 6d by the change in equilibrium employment equal to $L^D - L^C$. Formally, this effect is captured by the rightmost term in (19a) and (19b).

## 8 Calibration and Quantitative Results

As we saw previously, a change in property taxes produces a response in the model that depends on the structural parameters. This section describes the procedure used to calibrate the parameters in the model. Our strategy is based on matching the empirical estimates obtained with Italian data with the reduced-form effects predicted by the model.

As we discuss later, we will not target the reduced-form response of labor to changes in property taxes; instead, we use these estimates to perform a validation test for the model's predictions on employment. Finally, we use our main decomposition result to provide quantitative estimates for the housing wealth and firm collateral channel on employment.

### 8.1 Calibration Procedure

At first glance, the similarities between the empirical parametric specification and the equilibrium response predicted by the model suggest that the diff-in-diff estimator ($\beta_{y,i}$) in (5) is equivalent and directly comparable to the model's prediction ($\beta_{y,i}(\Theta)$) in (14). However, this conclusion is correct only if the diff-in-diff estimator identifies the average treatment effect of a property tax increase on treated municipalities.

In our case, the evidence presented in subsection 6.3 should reduce most concerns about potential confounding factors biasing the baseline results obtained with Italian municipal-level data. Therefore, it is reasonable to assume that our diff-in-diff estimator identifies the average treatment effect of a property tax increase and that our baseline estimation results in Table 2 provide helpful information to discipline the model.

As a notation reminder, recall that $\Theta = [\alpha, \beta, \nu, \epsilon, \sigma_f, \sigma_h, \phi_h, \phi_f]$ is the vector of structural parameters in our model. On the other hand, for outcome $y = \{l, c, p^h, p^f\}$, we denote

$\beta_{y,i}(\Theta)$, $\beta_{y,i}$, and $\widehat{\beta}_{y,i}$ as the model-implied reduced-form response, the diff-in-diff estimator and the point estimate obtained to a tax rate change $\Delta\tau^i$, respectively.

The characterization of the housing wealth and firm collateral channel in (18) and (17), showed us that real estate supply elasticities ($\sigma_h$ , $\sigma_f$) and collateral requirements ($\phi_h$ , $\phi_f$) are key parameters determining the magnitude of the housing wealth and firm collateral channel on employment. Therefore, we internally calibrate the subset of structural parameter denoted by $\Theta_{\text{in}} = [\sigma_h, \sigma_f, \phi_h, \phi_f]$. The remaining parameters $\Theta_{\text{out}} = [\alpha, \beta, \nu, \epsilon]$, are set to values generally used in the literature.

We define the calibration procedure for $\Theta_{\text{in}}$ by using the link between the set of reduced-form coefficients in the model (*i.e.* $\beta_{y,i}(\Theta)$) and $\Theta_{\text{in}}$. In particular, we can show that, for a given value of $\Theta_{\text{out}}$, $\{\sigma_h, \phi_h\}$ simultaneously pin-down the model-implied response of residential prices and consumption expenditure to higher residential taxes. Similarly, the model-implied response of commercial and residential prices to higher commercial taxes simultaneously are pinned down by $\{\sigma_f, \phi_f\}$.[21]

Consequently, we set $\{\sigma_h, \phi_h\}$ and $\{\sigma_f, \phi_f\}$ to match $\left\{\hat{\beta}_{p^h,h}, \hat{\beta}_{c,h}\right\}$ and $\left\{\hat{\beta}_{p^f,f}, \hat{\beta}_{p^h,f}\right\}$ with $\left\{\beta_{p^h,h}(\Theta), \beta_{c,h}(\Theta)\right\}$ and $\left\{\beta_{p^f,f}(\Theta), \beta_{p^h,f}(\Theta)\right\}$, respectively.

## 8.2 Calibration Results

Table 3 shows the values for the structural parameters in our model. The first four rows correspond to the values for the parameters defined externally, while the last four rows show the values of the parameters calibrated internally in our model.

For the parameters defined externally, we fix the labor share $\alpha$, Frisch elasticity $\nu$, and elasticity of substitution across varieties $\epsilon$ to 0.6, 1, and 4, respectively. This choice is consistent with what is commonly used in the business cycle literature. Finally, following Berger et al. (2018), we set the share of expenditure on housing goods $\beta$ to 0.8.

The calibrated values for the housing and commercial real estate supply elasticities are 5.74 and 3.81, respectively. These results are significantly lower than the housing supply elasticity of 16.67 estimated by Saiz (2010).[22] However, it is important to point out that the author uses changes in residential prices across US metropolitan areas during 1970-2000. In comparison, the targets for the supply elasticities in our paper are two moments estimated exploiting yearly changes in real estate prices across Italian municipalities during 2011-2012. Therefore, our calibration results for the supply elasticities of residential and commercial properties should capture short-run supply elasticities consistent with the long-run estimates found in the literature.

[21]See the online appendix for more details on this point.
[22]See TABLE III, column (4).

The collateral requirements for households and firms are calibrated to 0.15 and 0.22, respectively. We use the 2012 Italian Survey of Households, Income, and Wealth (SHIW) to compute some benchmark comparisons. In particular, we focus on households owning a single property that got a loan in the past three years, and the loan required real estate guarantees. Using this group of households, we compute the average loan-to-value ratio using data for the reported value of the loan and the subjective valuation of real estate assets. As a result, we obtain an average loan-to-value ratio for single house owners of 0.34, while for owners of a single commercial real estate property, the average loan-to-value ratio is 0.26. Compared to the average estimates obtained using household survey data for Italy, our model's calibration for the loan-to-value ratios are lower but not excessively far off.

### 8.3 Predictions for Employment: Validation and Robustness

The calibration procedure we detailed before does not target the estimates for the employment response to changes in property taxes. We use the estimates for employment to test our model's validity instead. In particular, we want to ensure that the model's employment predictions are consistent with the estimations obtained with Italian data.

The results from the validation exercise are reported in Table 4. The first column presents the model's predictions for $\beta_{l,h}(\Theta)$ and $\beta_{l,f}(\Theta)$ using the values of $\Theta$ reported in Table 3. The second column reproduces the point estimates for non-tradable employment growth in Table 2. Finally, the third column computes the 95% confidence intervals for the estimates of non-tradable employment.

For residential taxes, the model predicts that a one pp increase in the tax rate reduces employment growth by 0.071 pp, slightly under-predicting the point estimates by only 18%. However, $\beta_{l,h}(\Theta)$ is well within the 95% confidence interval.

For the increase in commercial real estate taxes, the model predicts that a one pp increase in the tax rate reduces non-tradable employment by 0.061 pp. In this case, the model over-predicts the point estimate by 26%. However, the model's prediction for $\beta_{l,f}(\Theta)$ is still within the 95% confidence interval.

The results in Table 4 show that the model's predictions are reasonably close to the non-targeted empirical counterparts. However, we still need to check if this conclusion remains after changing the value of the externally defined parameters. In the online appendix, we show that the model's predictions on employment are robust to changing the values of the Frisch elasticity ($\nu$) and the elasticity for varieties ($\epsilon$).

In conclusion, the model does a good job of replicating the estimates for non-tradable employment obtained with Italian data. With this in mind, we move on to quantifying the housing wealth and firm collateral channel on employment.e

## 8.4 Decomposing the Employment Response to Higher Property Taxes

As discussed previously, the response of employment to a change in residential and commercial taxes is partly explained by the housing wealth channel and firm collateral channel, respectively. Then, with the calibrated model, we can use the decomposition in (19a) and (19b) to compute the housing wealth and firm collateral channel on employment induced by higher property taxes.

Table 6 presents the quantitative decomposition for the employment response to higher property taxes. The first two columns, under label $(A)$, show the magnitude of the housing wealth (first row) and firm collateral channel (second row) on employment. The second and third columns, labeled $(B)$ and $(C)$, report the employment response due to labor supply shifts and other changes in labor demand, respectively. Finally, the fourth column reproduces the model's employment predictions, shown in Table 4. Notice that, by construction, the total effect on employment is equal to the sum of columns $(A)$, $(B)$, and $(C)$.

The first row of Table 6 shows that a one pp increase in residential taxes reduces employment growth by 0.036 pp due to the housing wealth channel. Furthermore, labor supply magnifies the employment growth decline by 0.046 pp because the negative *direct effect* of higher residential taxes on labor supply completely overshadows any increase in labor supply explained by the *indirect wealth effect*.[23] Lastly, as initially expected, labor growth increases by 0.011 pp due to additional demand-side changes. Nonetheless, the total net effect amounts to a 0.071 pp lower employment growth when residential taxes increase.

The second row of Table 6 shows that a one pp increase in commercial taxes reduces labor growth by 0.043 pp and 0.020 pp due to the firm collateral channel and additional demand-side changes, respectively. Conversely, employment increases by 0.002 pp because, in this case, only the *indirect wealth effect* on labor supply is present. Overall, employment growth drops by 0.061 pp after commercial real estate taxes increase.

## 8.5 Discussion on the Quantitative Results

We can draw several conclusions from the decomposition results reported on Table 6.

First and foremost, our quantitative results show that the housing wealth and firm collateral channel on employment are essential components of the overall reduced-form effect of property taxes on labor. Specifically, the housing wealth channel explains more than 50% of the 0.071 pp employment drop to a one pp increase in residential taxes.

[23] Specifically, our model predicts that, for a one pp increase in residential taxes, the magnitude of the *direct effect* and *indirect wealth effect* is -0.049 pp and 0.003 pp, respectively.

Meanwhile, the firm collateral channel represents 70% of the 0.061 pp employment growth decline due to a one pp increase in commercial real estate taxes.

Furthermore, we can also discuss the relative importance of each channel on employment. In particular, our model predicts that, when comparing a one pp increase in commercial taxes relative to an equivalent increase in residential tax changes, the firm collateral channel reduces employment growth by approximately 20% more than the housing wealth channel. Therefore, regarding magnitude, the firm collateral channel is relatively more important for employment changes after an exogenous increase in real estate prices.

Finally, the results in Table 6 also reveal the importance of the general equilibrium effect to account for the total response of labor to property taxes. First, our model explains that the higher response of employment to residential tax changes, relative to commercial tax changes, is because the negative response of labor supply attributed to the *direct effect*, only present when residential taxes increase, which dominates any increase in labor supply coming from the *indirect wealth effect*. However, we need to recognize that accounting for additional general equilibrium changes in labor demand is also essential to improve the model's ability to provide predictions for employment consistent with our data estimates.

## 9 Conclusions

This paper studies the employment consequences of a simultaneous drop in residential and commercial real estate prices. In particular, our paper focus on quantifying the relative importance of the housing wealth and firm collateral channel on employment. We identify two main difficulties in measuring each channel. First, it is unclear how to separate both channels affecting labor demand similarly. Second, other channels impact the labor market when real estate prices change. This paper provides a unifying approach to model and quantify the housing wealth and firm collateral channel on employment after a drop in real estate prices. In particular, our approach combines reduced-form empirical evidence from a property tax reform with a quantitative model.

On the empirical side, we exploit a differential increase in tax rates for residential and commercial properties across municipalities during the 2012 Italian property tax reform. We use a diff-in-diff design to estimate the differential effect of a property tax increase on non-tradable employment, consumption expenditure, and real estate prices. In our diff-in-diff specification, the change in residential and commercial property tax rates across municipalities are used as treatment intensity variables. Our estimation results show that higher property taxes (*i.e.* either to residential or commercial properties) are associated with lower growth in non-tradable employment, consumption expenditure, and real estate prices. Regarding the necessary conditions for identification with the diff-in-diff estimator, we find no evidence of systematic differences in pre-tax reform trends for all outcomes across municipalities and no anticipation effects from local authorities before the 2012 tax reform.

Even though the employment estimates are not direct measures for any of the two channels we want to quantify, these contain critical information to be used by a quantitative model with two types of real estate assets, differential property tax rates, and financial frictions to access loans. Moreover, the particular structure of our model creates two advantages. First, using the analytical solution for the model's equilibrium, we compute the differential response of employment, consumption, and real estate prices to higher property taxes that maps one-to-one with our diff-in-diff estimates. Second, we decompose the labor's response to higher property taxes into three parts; one capturing either the housing wealth channel–if residential taxes increase–or the firm collateral channel–if taxes for commercial properties increase, while the remaining parts representing adjustments of labor supply, and additional changes in labor demand due to a general equilibrium adjustment of prices and wages.

Next, employing a matching moment strategy, we use the empirical estimates to discipline the model. In particular, we calibrate the supply elasticities for residential and commercial properties and the collateral requirements for households and firms. Finally, we test the model's validity by comparing the predicted response of employment to changes in property taxes with the empirical counterparts obtained with Italian data. The results from this test show that the model does a reasonably good job replicating the estimates for employment obtained with municipal-level data for Italy.

The main quantitative results of our model are twofold. First, we find that both channels explain more than 50% of the labor decline due to higher property taxes. In particular, the model predicts that the firm collateral and housing wealth channels account for 70% and 51% of the decline in non-tradable employment after a drop in real estate prices induced by higher property taxes, respectively. Second, in terms of relative importance, the firm collateral channel seems to reduce employment by almost 20% more than the housing wealth channel after an increase in property taxes.

## 10 References

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# 11 Tables and Figures

## 11.1 Tables

**Table 1:** Summary Statistics - 2012: Municipal Level Variables

| | Mean | S.D | $P^{25}$ | $P^{50}$ | $P^{75}$ |
|---|---|---|---|---|---|
| Population | 8,278 | 44,961 | 1,209 | 2,819 | 6,919 |
| Area (mi$^2$) | 58.38 | 108.65 | 8.63 | 21.79 | 54.39 |
| Income$^{pc}$ | 11,376 | 2,961 | 8,854 | 11,740 | 13,469 |
| $L^{tot}$ | 2,193 | 16,502 | 139 | 489 | 1,554 |
| share $L^{ntrad}$ (%) | 41 | 14 | 31 | 41 | 50 |
| $\Delta\tau^h$ | 0.43 | 0.07 | 0.40 | 0.40 | 0.50 |
| $\Delta\tau^f$ | 0.24 | 0.10 | 0.16 | 0.25 | 0.31 |
| $\Delta L^{tot}$ | -0.17 | 7.47 | -3.52 | -0.67 | 2.54 |
| $\Delta L^{ntrad}$ | 2.44 | 7.95 | -2.20 | 1.28 | 5.67 |
| $\Delta C$ | -5.09 | 71.58 | -57.17 | -9.61 | 30.07 |
| $\Delta P^{House}$ | -1.81 | 4.03 | -4.06 | 0.00 | 0.00 |
| $\Delta P^{CRE}$ | -1.88 | 3.43 | -3.02 | 0.00 | 0.00 |

*Notes*: The table show summary statistics for the municipality-level data in 2012. Employment data comes from the ASIA yearly census. $L^{tot}$ and $L^{ntrad}$ refers to the total and non-tradable employment, respectively. Income$^{pc}$ and $C$ represent the real per capita value of income and consumption expenditure in car purchases; respectively, we use the CPI to deflate both variables (2010=100). Residential ($P^{House}$) and commercial real estate ($P^{CRE}$) property prices are defined as the average value per meter$^2$ across homogeneous real state markets. Variables with $\Delta$ are expressed in percentages.

**Table 2:** Baseline Estimation Results: 2012 Property Tax Reform

| | Non-Tradable Employment $(\widehat{\beta}_{l,i})$ | Consumption Expenditure $(\widehat{\beta}_{c,i})$ | Housing Price $(\widehat{\beta}_{p^h,i})$ | CRE Price $(\widehat{\beta}_{p^f,i})$ |
|---|---|---|---|---|
| $\Delta\tau^h_{m,t} \times \mathbb{1}\{t = 2012\}$ | -0.087*** | -0.517*** | -0.022** | -0.005 |
| | (0.015) | (0.145) | (0.009) | (0.010) |
| $\Delta\tau^f_{m,t} \times \mathbb{1}\{t = 2012\}$ | -0.045*** | -0.177 | -0.017*** | -0.032*** |
| | (0.011) | (0.120) | (0.006) | (0.008) |
| $\widehat{IQR}_y / IQR_{y,2012}(\%)$ | 19.5 | 6.77 | 11.8 | 17.3 |
| $N_{\text{obs}}$ | 43,540 | 34,881 | 38,731 | 29,471 |
| $N_{\text{mun}}$ | 6,220 | 6,104 | 5,534 | 3,687 |
| $R^2$ | 0.13 | 0.12 | 0.33 | 0.31 |

*Notes*: The table presents the baseline results. All dependent variables are expressed in growth rates. The sample used covers the period 2008-2014. The price of real estate assets is computed as the average value per squared meter across homogeneous real state markets within each municipality. Commercial real estate comprises all properties used in the retail sector, while residential properties are used for housing services only. Consumption expenditure is proxied by expenditures on new vehicles. Standard errors in parentheses are clustered at the local labor market level, *, **, *** indicate significance at the 10% 5% and 1% respectively.

**Table 3:** Model Calibration

| | Parameter | Value | Target |
|---|---|---|---|
| Labor Share | $\alpha$ | 0.6 | Common in literature |
| Frisch elasticity | $\nu$ | 1 | Common in literature |
| Elasticity of demand | $\epsilon$ | 5 | Common in literature |
| Exp. share goods | $\beta$ | 0.8 | Berger et al. (2018) |
| Supply elast. houses | $\sigma_h$ | 5.74 | $\hat{\beta}_{p^f,f}, \hat{\beta}_{p^h,f}$ |
| Supply elast. CRE | $\sigma_f$ | 3.81 | $\hat{\beta}_{p^f,f}, \hat{\beta}_{p^h,f}$ |
| LTV HH's | $\phi_h$ | 0.15 | $\hat{\beta}_{p^f,f}, \hat{\beta}_{p^h,f}$ |
| LTV firms | $\phi_f$ | 0.22 | $\hat{\beta}_{p^f,f}, \hat{\beta}_{p^h,f}$ |

**Table 4:** Validation Exercise: Model vs. Data

| | Model | Data | |
|---|---|---|---|
| | $\beta_{l,i}(\Theta)$ | $\hat{\beta}_{l,i}$ | 95 % CI |
| $\Delta\tau^h$ | 0.071 | 0.087 | [0.06, 0.12] |
| $\Delta\tau^f$ | 0.061 | 0.045 | [0.02, 0.07] |

**Table 5:** Employment Response: Decomposition

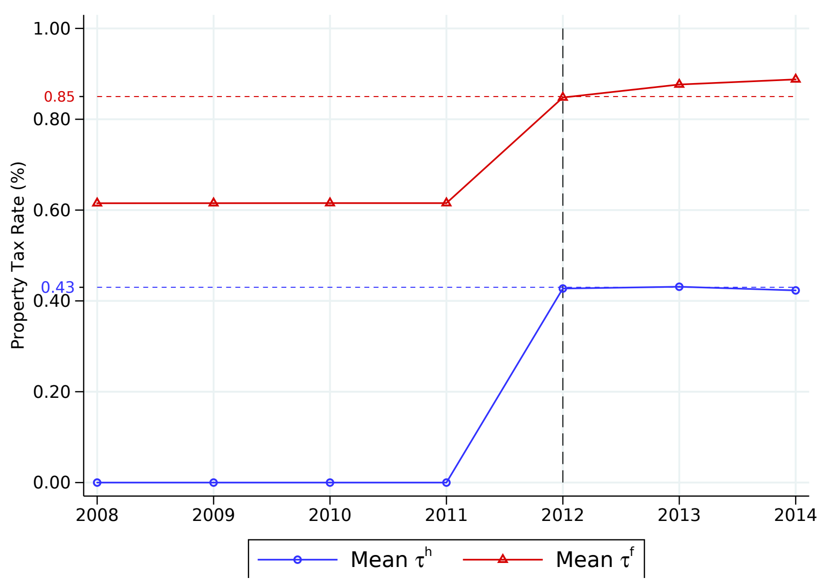
| | Housing Wealth | Firm Collateral | Labor Supply | Other Labor Demand | Total Effect |
|---|---|---|---|---|---|
| | $(A)$ | | $(B)$ | $(C)$ | $(A)+(B)+(C)$ |
| $\Delta\tau^h$ | -0.036 | | -0.046 | 0.011 | -0.071 |
| $\Delta\tau^f$ | | -0.043 | 0.002 | -0.020 | -0.061 |

**Table 6:** Household Wealth and Firm Collateral Channel

| | $\delta^i$ | $\beta_L$ | $\delta^i/\beta_L$ |
|---|---|---|---|
| $\delta_L^{wealth}$ | -0.073 | -0.074 | 98 % |
| $\delta_L^{coll}$ | -0.052 | -0.061 | 84 % |

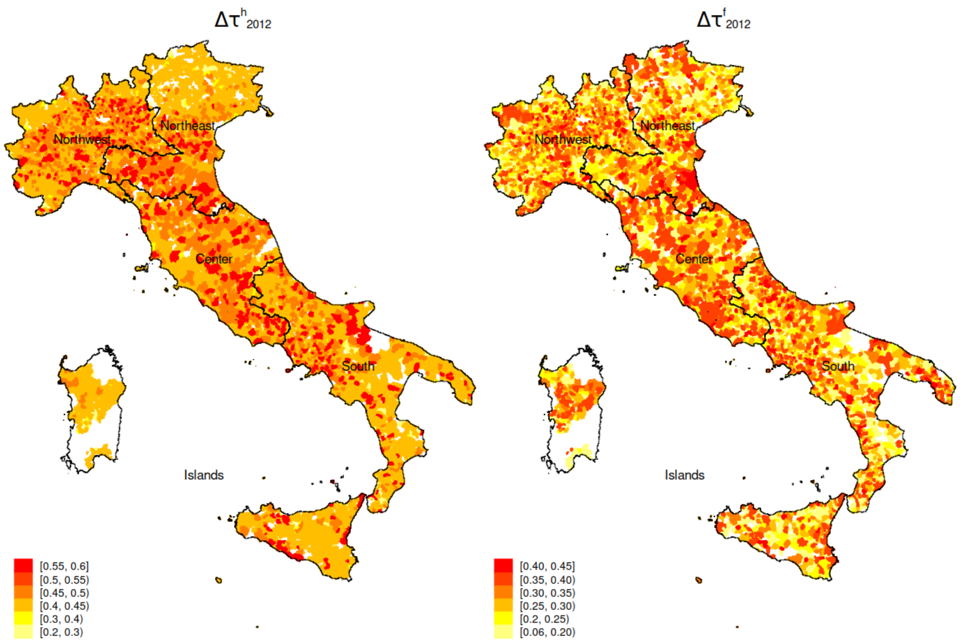
## 11.2 Figures

**Figure 1:** Average Property Tax Rates 2008-2015



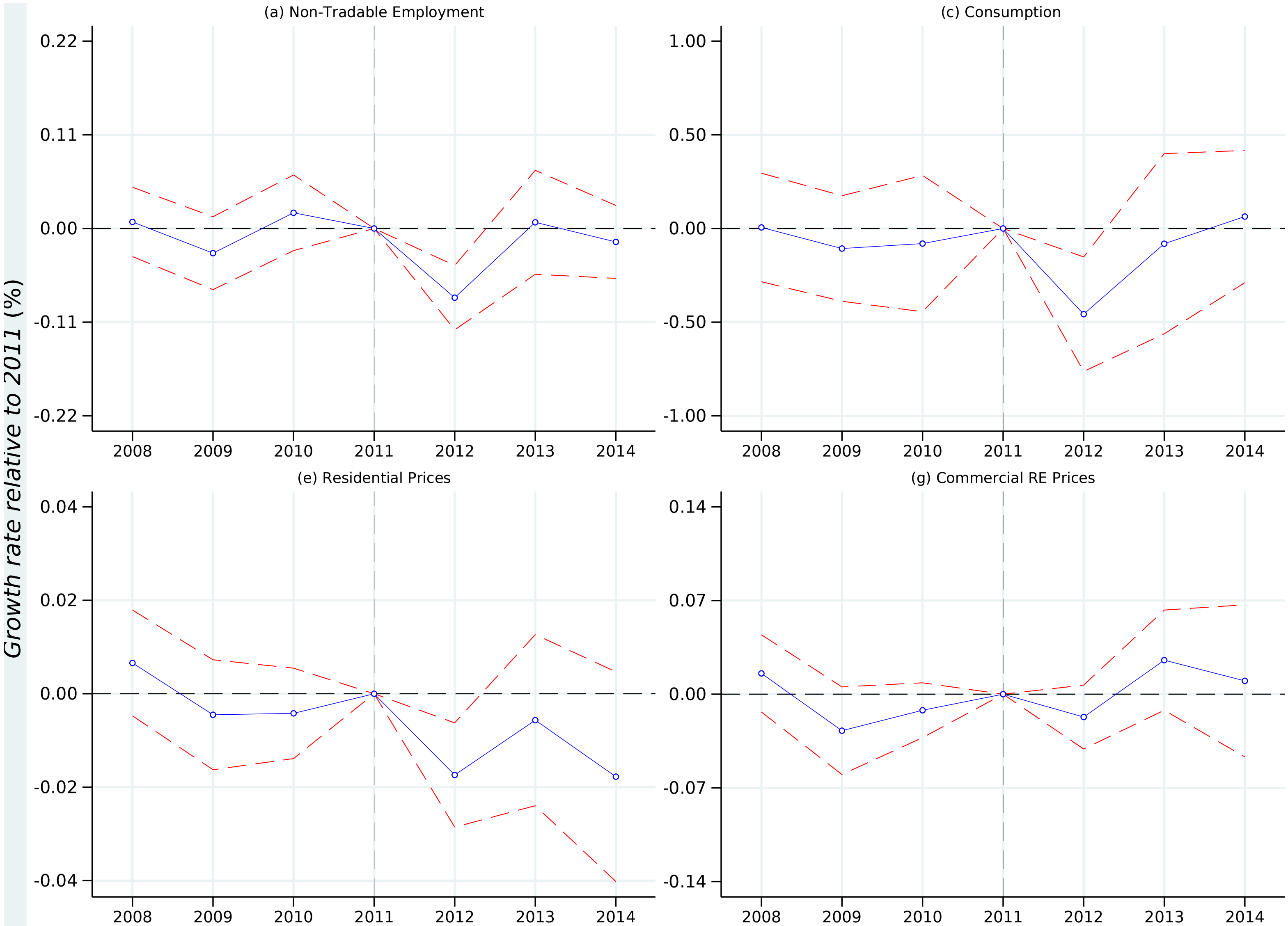

*Note:* The figure shows the yearly average property tax rate across municipalities for 2008-2015. The red line represents the average tax rate for residential properties (*principal*), and the blue line depicts the mean tax rate for commercial real estate properties (*secondary*).

## **Figure 2:** Property Tax Rate Changes - 2012 Tax Reform



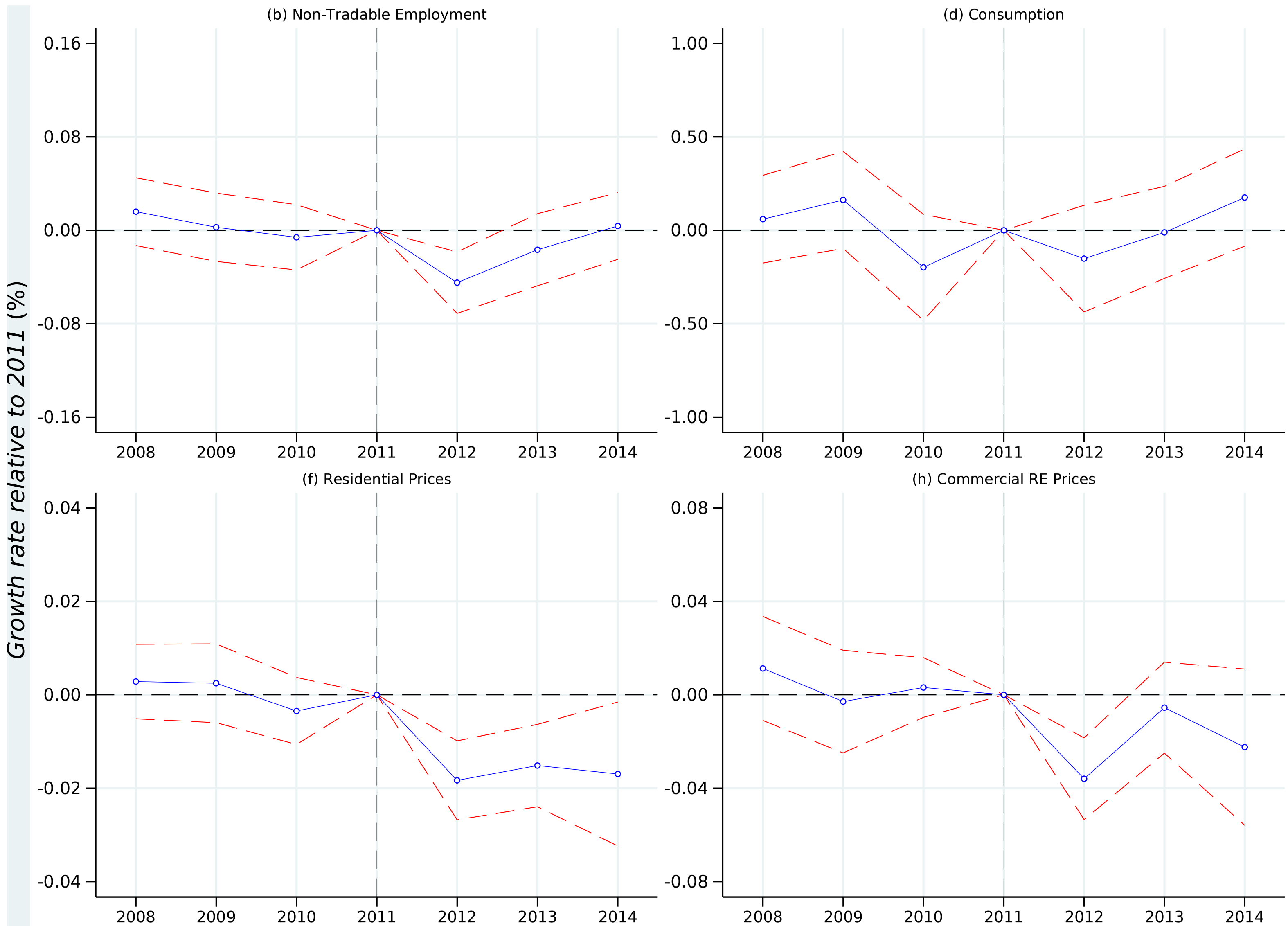

*Note:* The figure presents a heat-map plot of the change in property tax rates across municipalities in Italy during the 2012 property tax reform. The figure in panel (a) is for the residential tax rate, figure in panel (b) is for the commercial real estate tax rate.

**Figure 3:** Event Study: 2012 Change in the Tax rate for Residential Properties



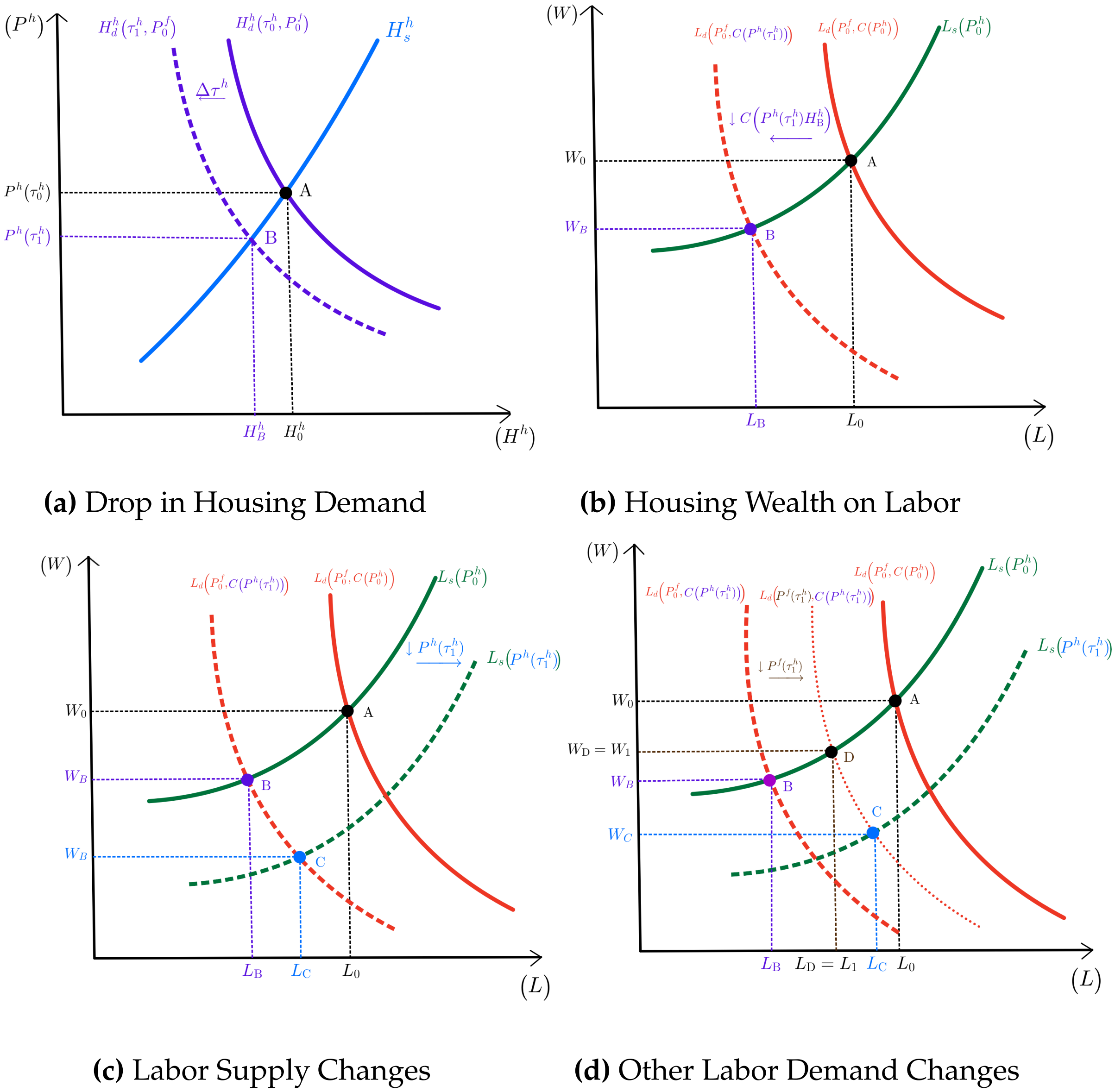

*Note:* The figure depicts the dynamic effect of higher residential property taxes on the main outcome variables. The solid blue lines plot the estimated coefficients, and the red dashed line represents the 95 percent confidence intervals. The hollowed blue circles represent the average growth difference in $t$ relative to 2011 for municipalities treated with a one pp higher $\Delta\tau^h$, where $t = 2008, 2009, 2010, 2012, 2013, 2014, 2015$. The sample includes 6,246 municipalities over the 2008- 2014 period. Standard errors clustered at the Local Labor Market level.

**Figure 4:** Event Study: 2012 Change in the Tax rate for Commercial Real Estate Properties




*Note:* The figure depicts the dynamic effect of higher commercial real estate property taxes on the main outcome variables. The solid blue lines plot the estimated coefficients, and the red dashed line represents the 95 percent confidence intervals. The hollowed blue circles represent the average growth difference in $t$ relative to 2011 for municipalities treated with a one pp higher $\Delta\tau^f$, where $t = 2008, 2009, 2010, 2012, 2013, 2014, 2015$. The sample includes 6,246 municipalities over the 2008- 2014 period. Standard errors clustered at the Local Labor Market-level.

**Figure 5:** The Effect of Higher Residential Taxes




**(a)** Drop in Housing Demand

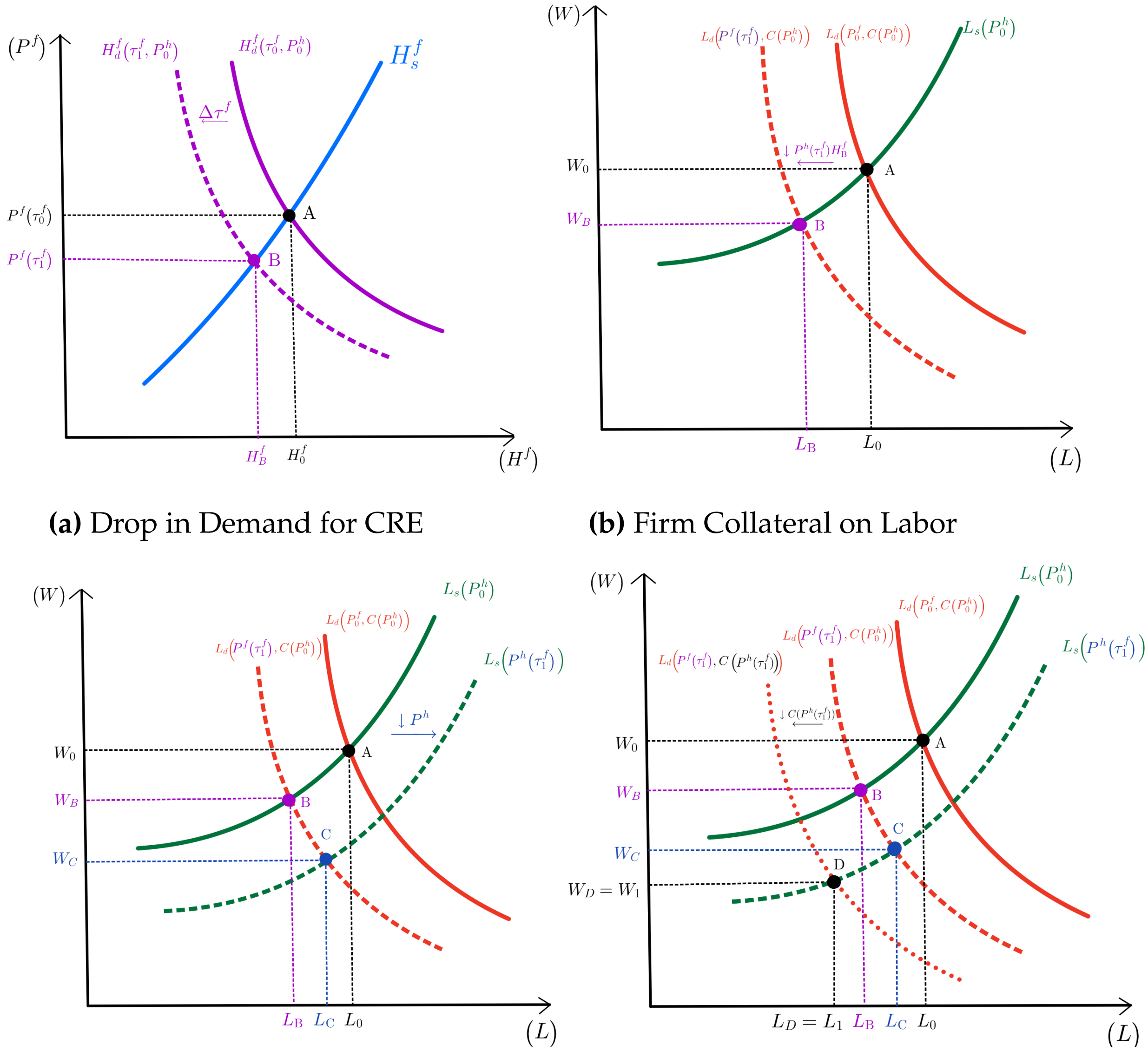
**(b)** Housing Wealth on Labor

**(c)** Labor Supply Changes

**(d)** Other Labor Demand Changes

*Note:* The figure depicts the effect of a higher tax rate on residential properties. Figure 5a shows the housing market's response to price and quantities. In the labor market, Figure 5b shows the housing wealth channel on employment, while Figure 5c and Figure 5d represent the general equilibrium adjustment of employment after the increase in commercial real estate taxes.

**Figure 6:** The Effect of Higher Commercial Real Estate Taxes




**(a)** Drop in Demand for CRE

**(b)** Firm Collateral on Labor

**(c)** Labor Supply Changes

**(d)** Other Labor Demand Changes

*Note:* The figure depicts the effect of a higher tax rate on commercial real estate properties. Figure 6a shows the response of price and quantities in the commercial real estate market. In the labor market, Figure 6b shows the collateral channel on employment, while Figure 6c and Figure 6d represent the general equilibrium adjustment of employment after the increase in commercial real estate taxes.

## Appendix A Constrained competitive equilibrium

We present the analytical solution for the constrained equilibrium in our model next.[24] Using the equilibrium wage to obtain the equilibrium employment:

$$L = \left[ \frac{\phi_f \phi_h^{\beta} (P^f)^{1+\sigma_f}}{\chi (P^h)^{1-\beta} (1 + \tau^h + \phi_f)} \right]^{\frac{\nu}{1+\nu}} \tag{A1}$$

alternatively:

$$L = \left[ \phi_f^{1+\alpha(\epsilon-1)} \left( \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon} \left( \frac{\phi_h^{\beta}}{\chi} \right)^{\nu+\alpha(\epsilon-1)} \frac{C}{(P^f)^{(1-\alpha)(\epsilon-1)} (1 + \tau^f + \phi_f)^{\epsilon} ((P^h)^{1-\beta} (1 + \tau^h + \phi_h))^{\nu+\alpha(\epsilon-1)}} \right]^{\frac{\nu}{1+\nu+\alpha(\epsilon-1)}} \tag{A2}$$

now, for the equilibrium price of commercial properties, we get the following expressions:

$$P^f = \left[ \left( \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon(1+\nu)} \frac{\left( \phi_f \phi_h^{\beta} \right)^{\alpha(\epsilon-1)\nu} C^{1+\nu}}{\chi^{\alpha(\epsilon-1)\nu} (1 + \tau^f + \phi_f)^{\epsilon(1+\nu)} (1 + \tau^h + \phi_h)^{\alpha(\epsilon-1)\nu} (P^h)^{\alpha(\epsilon-1)(1-\beta)\nu}} \right]^{\frac{1}{A_f}} \tag{A3}$$

where, $A_f = (1 + \sigma_f)(1 + \nu + \alpha(\epsilon - 1)) + (1 + \nu)(1 - \alpha)(\epsilon - 1)$. Next, regarding the equilibrium price of residential properties:

$$P^h = \left[ \frac{(P^f)^{1+\sigma_f} (1 + \tau^f + \epsilon\phi_f)}{(\epsilon - 1)(1 + \tau^h + \phi_h)} \right]^{\frac{1}{1+\sigma_h}} \tag{A4}$$

alternatively, we can also express residential prices as follows:

$$P^h = \left[ \left( \frac{\phi_h^{1+\nu(\alpha(\epsilon-1)\beta)+1}}{\epsilon^{\epsilon(1+\nu)}} \right)^{\frac{1}{\alpha(\epsilon-1)}} \left( \frac{(1 + \tau_f + \epsilon\phi_f)^{1+\nu+\alpha(\epsilon-1)}}{(1 + \tau^f + \phi_f)^{\epsilon(1+\nu)} (1 + \tau^h + \phi_h)^{(1+\nu)(1+\alpha(\epsilon-1))}} \right)^{\frac{1}{\alpha(\epsilon-1)}} \frac{(\epsilon - 1)^{\frac{1-\alpha+\nu}{\alpha}} \phi_f^{\nu}}{(P^f)^{\frac{(1-\alpha)(1+\nu)}{\alpha}}} \right]^{\frac{1}{1+\sigma_h+(1-\beta)\nu}} \tag{A5}$$

finally, the equilibrium consumption expenditure will be:

$$C = \phi_h (P^h)^{1+\sigma_h} \tag{A6}$$

[24] See the online appendix. for the details on the mathematical derivation.

## Appendix B Proof of Propositions

Proof of Proposition 1. Recall that, if $\frac{\tau^h}{1+\phi_h}$, $\frac{\tau^f}{1+\phi_f}$ and $\frac{\tau^f}{1+\epsilon\phi_f}$ are small enough, then:

$$\ln\left(1+\tau^i+\phi_i\right) \approx \ln\left(1+\phi_i\right) + \frac{\tau^i}{1+\phi_h} \text{ for } i = \{h, f\} \tag{B7a}$$

$$\ln\left(1+\tau^f+\epsilon\phi_f\right) \approx \ln\left(1+\epsilon\phi_f\right) + \frac{1+\tau^f}{1+\epsilon\phi_f} \tag{B7b}$$

Applying logs to (A1), (A3), (A4), and (A6) and using the approximations (B7a), (B7b) we obtain a linear system of equations that can be solved as a function of $\left\{\tau^h, \tau^f\right\}$ **QED**.

Proof of Proposition 2. Using the log-linear system of equations from Proposition 1, we replace $\left\{\tau^{h,\text{HIGH}}, \tau^{f,\text{HIGH}}\right\}$ and $\left\{\tau^{h,\text{low}}, \tau^{f,\text{low}}\right\}$ and compute the difference between both equilibria for all variables of interest:

$$l = \beta_{l,h}(\Theta)\Delta\tau^h + \beta_{l,f}(\Theta)\Delta\tau^f \tag{B8a}$$

$$c = \beta_{c,h}(\Theta)\Delta\tau^h + \beta_{c,f}(\Theta)\Delta\tau^f \tag{B8b}$$

$$p^h = \beta_{p^h,h}(\Theta)\Delta\tau^h + \beta_{p^h,f}(\Theta)\Delta\tau^h \tag{B8c}$$

$$p^f = \beta_{p^f,h}(\Theta)\Delta\tau^h + \beta_{p^f,f}(\Theta)\Delta\tau^h \tag{B8d}$$

where:

$$\begin{aligned}
\beta_{l,h}(\Theta) &= \frac{1}{1+\nu}\left[(1+\sigma_f)\beta_{p^f,h}(\Theta) - (1-\beta)\beta_{p^h,h}(\Theta) - \frac{1}{1+\phi_h}\right] \\
\beta_{l,f}(\Theta) &= \frac{1}{1+\nu}\left[(1+\sigma_f)\beta_{p^f,f}(\Theta) - (1-\beta)\beta_{p^h,f}(\Theta)\right] \\
\beta_{c,h}(\Theta) &= (1+\sigma_h)\beta_{p^h,h}(\Theta) \\
\beta_{c,f}(\Theta) &= (1+\sigma_f)\beta_{p^h,f}(\Theta) \\
\beta_{p^h,h}(\Theta) &= -\frac{1}{1+\sigma_h}\left[\frac{1}{1+\phi_h} - (1+\sigma_f)\beta_{p^f,h}(\Theta)\right] \\
\beta_{p^h,f}(\Theta) &= \frac{1}{1+\sigma_h}\left[(1+\sigma_f)\beta_{p^f,f}(\Theta) + \frac{1}{1+\epsilon\phi_f}\right]
\end{aligned}$$

$$\beta_{p^f,h}(\Theta) = -\frac{\alpha(\epsilon-1)\nu(\sigma_h+\beta)+(1+\nu)(1+\sigma_h)}{(\epsilon-1)(1+\phi_h)A_{hf}}$$

$$\beta_{p^f,f}(\Theta) = \frac{1}{A_f}\left[\Big((1+\nu)(1+\sigma_h)-\alpha(\epsilon-1)(1-\beta)\nu\Big)\beta_{p^h,f}(\Theta)-\frac{\epsilon(1+\nu)}{1+\phi_f}\right]$$

and $A_{hf}=\alpha(1+\sigma_f)(1+\sigma_h+(1-\beta)\nu)+(1-\alpha)(1+\sigma_h)(1+\nu)$. **QED**.

Proof of Proposition 3. Let $\Delta\tau^h>0$, and $\Delta\tau^f=0$. Computing $l=\ln L^{\text{HIGH}}-\ln L^{\text{low}}$ with (A2) and totally differentiating the resulting expression with respect to $\Delta\tau^h$

$$\frac{dl}{d\Delta\tau^h}=\frac{\nu}{1+\nu+\alpha(\epsilon-1)}\left[\frac{dc}{d\Delta\tau^h}-\Big(\nu+\alpha(\epsilon-1)\Big)\left((1-\beta)\frac{dp^h}{d\Delta\tau^h}+\frac{1}{1+\phi_h}\right)-(1-\alpha)(\epsilon-1)\frac{dp^f}{d\Delta\tau^h}\right] \tag{B11}$$

using (A6) to compute $dc/d\Delta\tau^h$

$$\frac{dc}{d\Delta\tau^h}=(1+\sigma_h)\frac{dp^h}{d\Delta\tau^h} \tag{B12}$$

to compute $dp^h/d\Delta\tau^h$, first we obtain $p^h=\ln P^{h,\text{HIGH}}-\ln P^{h,\text{low}}$ with (A5) and we totally differentiate the resulting expression with respect to $\Delta\tau^h$

$$\frac{dp^h}{d\Delta\tau^h}=-\frac{1}{1+\sigma_h+(1-\beta)\nu}\left(\frac{(1+\nu)(1+\alpha(\epsilon-1))}{1+\phi_h}+\frac{(1-\alpha)(\epsilon-1)}{\alpha}\frac{dp^f}{d\Delta\tau^h}\right) \tag{B13}$$

replacing (B13) into (B12)

$$\frac{dc}{d\Delta\tau^h}=-\frac{1+\sigma_h}{1+\sigma_h+(1-\beta)\nu}\left(\frac{(1+\nu)(1+\alpha(\epsilon-1))}{1+\phi_h}+\frac{(1-\alpha)(\epsilon-1)}{\alpha}\frac{dp^f}{d\Delta\tau^h}\right) \tag{B14}$$

replacing equation (B14) into (B11)

$$\begin{aligned}\frac{dP^h}{d\Delta\tau^h}=&\frac{\nu}{1+\nu+\alpha(\epsilon-1)}\Bigg[-\frac{(1+\sigma_h)(1+\nu)(1+\alpha(\epsilon-1))}{A_h(1+\phi_h)}-(\nu+\alpha(\epsilon-1))\left(\frac{1}{1+\phi_h}+(1-\beta)\frac{dp^h}{d\Delta\tau^h}\right)\\&-(1-\alpha)\left(\frac{(1+\sigma_h)(1+\nu)}{\alpha A_h}+\epsilon-1\right)\frac{dp^f}{d\Delta\tau^h}\Bigg]\end{aligned} \tag{B15}$$

we get the decomposition in (19a), replacing $\delta^{\text{wealth}}(\Theta)$ in (17) into (B15) and denoting $\frac{dl}{d\Delta\tau^h} = \beta_{l,h}(\Theta)$, $\frac{dP^h}{d\Delta\tau^h} = \beta_{p^h,h}(\Theta)$, and $\frac{dP^f}{d\Delta\tau^h} = \beta_{p^f,h}(\Theta)$.

Next, let $\Delta\tau^f > 0$, and $\Delta\tau^h = 0$. Obtaining $l = \ln L^{\text{HIGH}} - \ln L^{\text{low}}$ with (A1) and totally differentiating the resulting expression with respect to $\Delta\tau^f$

$$\frac{dl}{d\Delta\tau^f} = \frac{1}{1+\nu}\left[(1+\sigma_f)\frac{dp^f}{d\Delta\tau^f} - (1-\beta)\frac{dp^h}{d\Delta\tau^f}\right] \tag{B16}$$

computing $dp^f/d\Delta\tau^f$ by obtaining $p^f = \ln P^{f,\text{HIGH}} - \ln P^{f,\text{low}}$ with (A3)

$$\frac{dp^f}{d\Delta\tau^f} = \frac{1}{A_f}\left[\Big((1+\nu)(1+\sigma_h) - \alpha(\epsilon-1)(1-\beta)\nu\Big)\frac{dp^h}{d\Delta\tau^f} - \frac{\epsilon(1+\nu)}{1+\phi_f}\right] \tag{B17}$$

replacing (B17) into (B16)

$$\frac{dl}{d\Delta\tau^f} = -\frac{\nu\epsilon(1+\sigma_f)}{A_f(1+\phi_f)} - \frac{(1-\beta)\nu}{1+\nu}\left[1+\frac{\alpha(\epsilon-1)(1+\sigma_f)}{A_f}\right]\frac{dp^h}{d\Delta\tau^f} + \frac{\nu(1+\sigma_h)(1+\sigma_f)}{A_f}\frac{dp^h}{d\Delta\tau^f} \tag{B18}$$

let $\frac{dl}{d\Delta\tau^f} = \beta_{l,f}(\Theta)$ and $\frac{dP^h}{d\Delta\tau^f} = \beta_{p^h,f}(\Theta)$. Then, the decomposition in (19b) can be obtained by replacing $\delta^{\text{coll}}(\Theta)$ in (18) into (B18) **QED**.