Who Bears the Burden of Local Taxes?

– Online Appendix –

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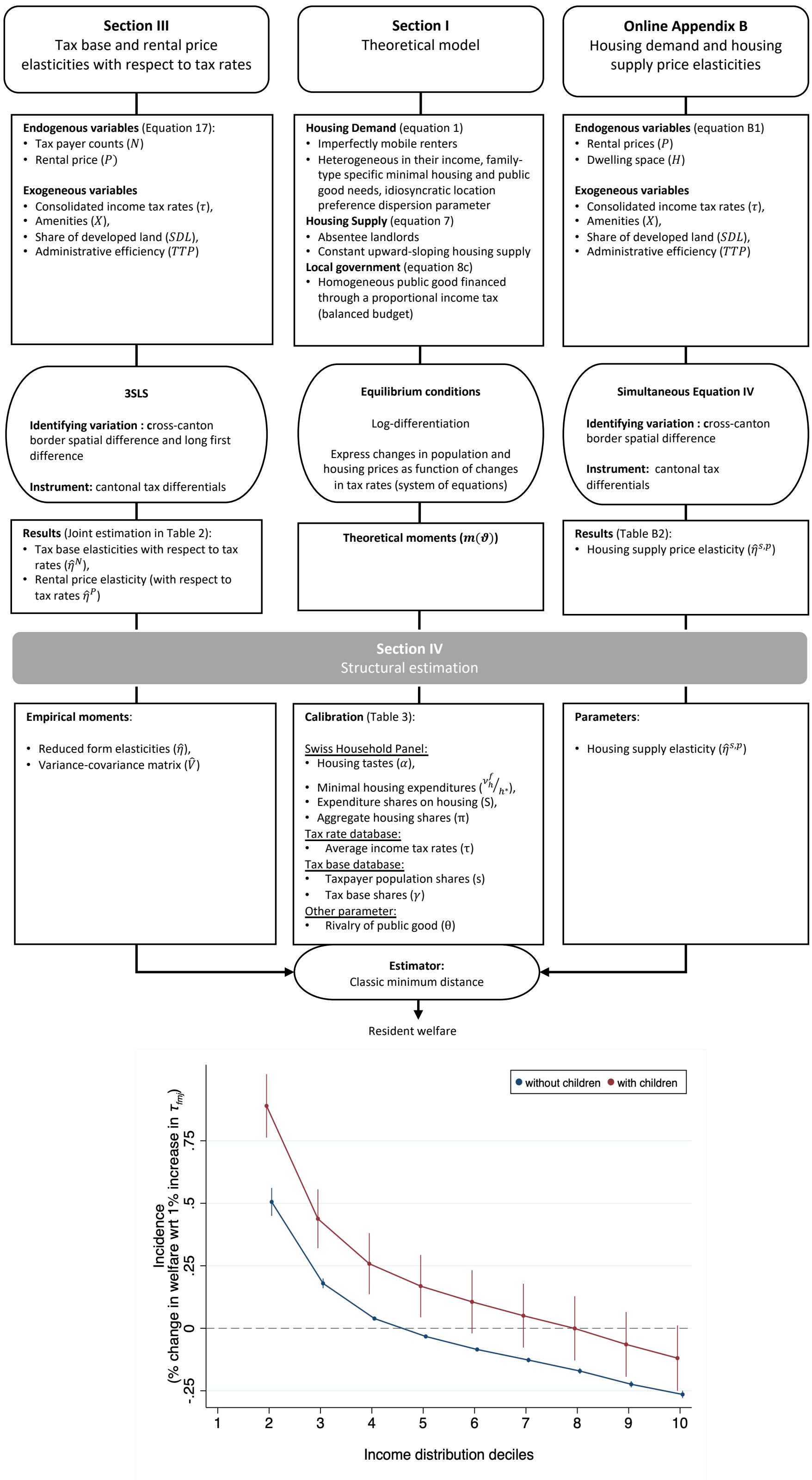
A Schematic overview



B Housing supply and demand

Here, we describe our estimation of the price elasticity of housing supply, a parameter required for our structural estimation. Housing supply depends both on physical construction costs and on administrative costs of (re-)zoning. We use instrumented changes in local income tax rates as a demand shifter allowing us to identify supply responses.

B.1 A simultaneous-equation IV framework

Our starting point is the following simultaneous-equation model for a cross-section of municipalities j:

$$\Delta \ln P_j = \frac{1}{\eta^{d,p}} \Delta \ln H_j + \eta^p \boldsymbol{\Delta} \ln \tau_j + \boldsymbol{\mu} \mathbf{X}_j + \phi_c + \epsilon_j^d \tag{B1a}$$

and

$$\Delta \ln P_j = \frac{1}{\eta^{s,p}} \Delta \ln H_j + \beta_1 SDL_j + \beta_2 TTP_j + \boldsymbol{\mu} \mathbf{X}_j + \phi_c + \epsilon_j^s \,, \tag{B1b}$$

where Δ represents long first differences. P denotes residual housing prices, H the residential housing stock, τ the personal income tax rate, **X** is a vector of local amenities (accessibility, exposure to natural risks, architectural heritage, and winter sunlight hours), SDL is the share of developed land, TTP ("time to permit") is a proxy for local administrative efficiency, and ϕ_c are canton fixed effects.[1]

For our administrative efficiency measure, we draw on the universe of individual-level building permits issued in Switzerland over the 1997-2003 period (i.e. prior to our main data period of 2004-2014). Our permits data include the projected costs, building type (e.g. a garage), type of project (e.g. renovation), and the number of structures (e.g. two garages). We compute, for all successful applications, the duration from the initial request to the award of the building permit, measured in months. We then perform a hedonic regression of time-to-permit on the observable characteristics of the project and municipality and year fixed effects. The estimated coefficients on the municipality fixed effects then serve as our proxy for local administrative efficiency (TTP).

As a second determinant of housing supply, we consider *topographic constraints*. We draw on a cross section of data indicating the most relevant form of land use within 100×100m grid cells across Switzerland for the period 1979 to 1985. We combine this information with digital height model data that report the gradient of the surface.[2] We define 'developable' land as the total surface area minus unproductive areas, forests and remaining unbuilt land

[1]The four time-invariant municipality-level amenity variables are proprietary data of Wüest Partner AG.

[2]Both data sets are produced by the Swiss Federal Statistics Office. The land use data are publicly available here. They distinguish 17 land-use types, which we aggregate into four broader categories. The first category is 'developed land', consisting of (i) industrial and commercial areas, (ii) residential and public buildings, (iii) transport areas, (iv) special infrastructure and (v) recreational areas. The second category is 'agricultural land' and consists of (i) horticultural and viticultural areas, (ii) arable land, (iii) meadows and (iv) pastures. The third category contains forests. Finally, we define 'unproductive areas' as including (i) lakes, (ii) rivers, (iii) unproductive vegetation, (iv) barren land and (v) glaciers and perpetual snow. The Digital Height Model (DHM25) data have been developed by the Geographic Information System group at the University of Lausanne.

with a slope greater than 20 percent (gradient of 11.3 degrees).[3] The ratio of developed land to developable land yields the share of developed land (SDL).

The model described by equations (B1a) and (B1b) identifies the elasticity of housing supply ($\eta^{s,p}$), contingent on a set of exclusion restrictions and validity conditions.

The exclusion restrictions we impose are that housing demand shifters do not affect housing supply, that is, we need that $cov(\Delta \ln \tau, \epsilon^s) = 0$. One concern is that changes in local income tax rates $\Delta \ln \tau$ could also lead to shifts in the supply curve. The atomistic absentee landlord described in Section I.B differs from our empirical setting insofar as rental income in Switzerland is taxed by the jurisdiction where the dwelling is located. We show in Appendix H that the supply side of the model is independent of changes in income taxes if landlords' running costs are tax deductible or taxed at the same rate as income. While mortgage interest, property tax payments and maintenance costs can be deducted from income taxes in Switzerland, transaction taxes are not deductible, and capital gains are in some places taxed at a different rate than the income tax. We exploit the heterogeneity in tax laws across Swiss cantons to filter out jurisdictions where changes in income tax rates are statutorily linked to changes in taxes that affect supply. Specifically, we replace $\Delta \ln \tau_j$ in (B1a) by a vector $\boldsymbol{\Delta \ln \tau}_j = [\Delta \ln \tau_j \quad \Delta \ln \tau_j \times NCM_c \quad \Delta \ln \tau_j \times PT_c \quad \Delta \ln \tau_j \times TT_c]'$ and $\boldsymbol{\eta^p} = [\eta^{d,p} \quad \eta^{d,p \times NCM} \quad \eta^{d,p \times PT} \quad \eta^{d,p \times TT}]$. Dummy variables indicate the cantons in which municipalities are not restricted to use the same multiplier for capital gains and personal income taxes (NCM, for no common multiplier), and cases in which municipalities have autonomy to set property tax rates (PT) and transaction tax rates (TT). The main effect $\Delta \ln \tau_j$ then measures the effect of local income taxes as measured in jurisdictions where changes in these taxes directly affect housing demand but not housing supply.

Valid identification furthermore requires that the demand shifter be exogenous to the system of equations, i.e. $cov(\Delta \ln \tau, \epsilon^d) = 0$. We however expect that local tax rates are endogenous with respect to local housing demand, in first-differences as well as in levels. To address the endogeneity of the tax rate, we turn to a two-step estimation on our sample of border municipalities.

Specifically, we back out the implied housing supply elasticity by estimating the following reduced-form equations separately,

$$\nabla \Delta \ln H_j = \boldsymbol{\eta^s} \boldsymbol{\nabla \Delta \ln \tau}_{jk} + \beta_1 \nabla SDL_{jk} + \beta_2 \nabla TTP_{jk} + \boldsymbol{\mu} \boldsymbol{\nabla X}_{jk} + \phi_c + \varepsilon_{jk} \tag{B2}$$

$$\nabla \Delta \ln P_{jk} = \boldsymbol{\eta^p} \boldsymbol{\nabla \Delta \ln \tau}_{jk} + \beta_1 \nabla SDL_{jk} + \beta_2 \nabla TTP_{jk} + \boldsymbol{\mu} \boldsymbol{\nabla X}_{jk} + \phi_c + \varepsilon_{jk}, \tag{B3}$$

where ∇ indicates the cross-canton spatial difference within pairs of municipalities jk in two neighboring cantons, c and d, with $(j \in c) \neq (k \in d \neq c)$. The vector $\boldsymbol{\nabla \Delta \ln \tau}_{jk}$ is instrumented with the vector $\boldsymbol{\nabla \Delta \ln \tau}_{cd}$. The parameter vectors are $\boldsymbol{\eta^s} = [\eta^s \quad \eta^{s \times \mathrm{ncm}} \quad \eta^{s \times \mathrm{pt}} \quad \eta^{s \times \mathrm{tt}}]$, $\boldsymbol{\eta^p} = [\eta^p \quad \eta^{p \times \mathrm{ncm}} \quad \eta^{p \times \mathrm{pt}} \quad \eta^{p \times \mathrm{tt}}]$ and coefficients of interest are η^s and η^p, respectively. The implied housing supply elasticity is given by

[3] Forest areas in Switzerland are protected by federal law and can only be cleared in case of an evident public interest, in which case an identical surface has to be reforested within the same region.

$$\widehat{\eta}^{s,p} = \frac{\widehat{\eta}^{s}}{\widehat{\eta}^{p}},$$

where standard errors can be calculated using the delta method.

B.2 Results

Table B1 presents the results of the simultaneous-equation model using the full set of municipalities. Column (1) does not include any control. In column (2), we control for amenities differentials among municipalities that are likely to influence housing demand, and for our two supply shifters, the share of developed land and the time-to-permit. The estimated housing supply elasticity varies between 0.63 (column 1) and 0.88 (column 3) depending on the inclusion of fiscal controls. The share of developed land is also statistically significant, while the time-to-permit does not seem to impact housing supply.

Table B1: Simultaneous equation estimates

	Rental price growth rate		
	(1)	(2)	(3)
Demand equation (B1a):			
Housing stock ($\widehat{\eta}^{d,p}$)	-1.605	-1.315**	-1.345**
	(1.444)	(0.602)	(0.633)
Local income tax ($\widehat{\eta}^{p,\tau}$)	-0.406***	-0.440***	-0.713*
	(0.143)	(0.118)	(0.376)
Supply equation (B1b):			
Housing stock ($\widehat{\eta}^{s,p}$)	0.632***	0.640***	0.881***
	(0.222)	(0.216)	(0.342)
Share of developed land ($\widehat{\beta}_1$)	0.082***	0.160***	0.128***
	(0.028)	(0.044)	(0.038)
Time-to-permit ($\widehat{\beta}_2$)	0.001	-0.003	-0.002
	(0.007)	(0.006)	(0.005)
Canton FE	YES	YES	YES
Amenity controls	NO	YES	YES
Fiscal controls	NO	NO	YES
# of observations	1,814	1,814	1,814

Notes: Standard errors in parentheses. Weighted by log municipal population in 2000 (data source: Swiss Federal Statistical Office (2016)). Housing demand and supply elasticities have already been transformed for direct interpretation. Amenity controls include indices of accessibility, exposure to natural risks, architectural heritage, and hours of sunlight. Fiscal controls include the interactions between the income tax rate and dummy variables NCM, PT, and TT. ***p<0.01, **p<0.05, *p<0.1. Data source for housing stock: Swiss Federal Statistical Office (2012) (for other data sources, see notes to Table **??**).

Table B2 presents our estimates of the housing supply elasticity that address the endogeneity of tax rates. Columns (1) and (2) show the OLS and 2SLS estimations of equation (B2), while columns (3) and (4) show the OLS and 2SLS estimations of equation (B3). Taking the ratio of the point estimates of columns (1) and (3), or (2) and (4), yields an implied estimate of the price elasticity of housing supply. The OLS estimate is lower in our border municipality sample compared to the full set of municipalities (see column 3 of Table B1). The IV implied elasticity equals 0.32, half the size of the OLS estimate. We retain this value for our calibration of the structural model.

Table B2: Supply equation IV estimates

	Spatial difference of dwelling space growth rate		Spatial difference of rental price residual growth rate	
	(1)	(2)	(3)	(4)
Dwelling space elasticity of income taxes ($\widehat{\eta}^{s,\tau}$)	-1.077***	-0.397		
	(0.288)	(0.406)		
Rental price elasticity of income taxes ($\widehat{\eta}^{p,\tau}$)			-1.409***	-1.231***
			(0.311)	(0.496)
Implied Housing Supply Elasticity $(\widehat{\eta}^{s,p})_{OLS}$: 0.764*** (0.265)				
Implied Housing Supply Elasticity $(\widehat{\eta}^{s,p})_{IV}$: 0.323 (0.354)				
Amenity controls	YES	YES	YES	YES
Fiscal controls	YES	YES	YES	YES
Origin canton FE	YES	YES	YES	YES
# of observations	3,530	3,530	3,530	3,530
# of origin clusters	812	812	812	812
# of dest. clusters	812	812	812	812
Instrument	–	Canton tax differential	–	Canton tax differential
Kleibergen-Paap F Stat	–	16.89	–	16.89
Estimator	OLS	2SLS	OLS	2SLS

Notes: Two-way cluster robust standard errors at origin and destination municipality level in parentheses. The sample consist of cross-canton pairs of municipalities with a pairing road distance of 10 km. Regressions are weighted by the log population in 2000 of the smallest municipality in the pair. Columns (1) and (2) come from the estimation of equation (B2), while columns (3) and (4) come from the estimation of equation (B3). The implied housing supply elasticity $(\widehat{\eta}^{s,p})_{OLS}$ comes from the ratio of point estimate in column (1) and column (3). The implied housing supply elasticity $(\widehat{\eta}^{s,p})_{IV}$ comes from the ratio of point estimate in column (2) and column (4). The corresponding standard errors are calculated using the delta method.Amenity controls include indices of accessibility, exposure to natural risks, architectural heritage, and hours of sunlight. Fiscal controls include the interactions between the income tax rate and dummy variables NCM, PT, and TT. ***p<0.01, **p<0.05, *p<0.1.

C Building blocks of the empirical model

In this Section, we gradually build up to our preferred specification, the long first-differences cross-border IV design, starting from panel OLS estimations for the full sample of Swiss municipalities. We begin the analysis by estimating a standard panel model featuring municipality and canton-year fixed effects. We then turn to an instrumental variable strategy to address the endogeneity of local tax rates.

C.1 OLS estimation

As a natural starting point, we first estimate a standard panel-data model:

$$\ln y_{jt} = \eta^y \ln \tau^y_{jt} + \phi_j + \phi_{ct} + \varepsilon^y_{jt}, \tag{C1}$$

where y_{jt} is either the count of taxpayers belonging to a specific household type, or the price of housing in municipality j and canton c at time $t \in [2004, ..., 2014]$, and $\ln \tau^y_{jt}$ is the log consolidated (canton + municipal + church) tax rate as relevant to the associated regressand y. Municipality fixed effects, ϕ_j, absorb time-invariant factors, and ϕ_{ct} is a canton-year fixed effect such that our identification comes from municipalities in the same canton changing their tax multipliers at different points in time. Standard errors are clustered at the municipality level. Since housing price data are more reliable in larger municipalities, we weight our main regressions by the log of population in 2000.

C.2 Instrumenting local tax rates

Eventually, we restrict the sample to municipalities that are located close to a canton border, following the IV approach developed in Raphaël Parchet (2019). We apply a cross-canton spatial difference estimation strategy, instrumenting the differential in the consolidated tax rate with the differential in the cantonal tax rate.

Our baseline panel-data estimating equation thus becomes (see also equations 17a-17g):

$$\nabla \ln y_{jkt} = \eta^y \nabla \ln \tau^y_{jkt} + \phi_{jk} + \phi_{ct} + \varepsilon^y_{jkt}, \tag{C2}$$

where ∇ indicates the cross-canton spatial difference within pairs of municipalities jk in two neighboring cantons, c and d, with $(j \in c) \neq (k \in d \neq c)$. Municipality-pair directional fixed effects, ϕ_{jk}, absorb time-invariant factors, and ϕ_{ct} is an origin canton-year fixed effect such that our identification comes from municipalities in the same canton but bordering different neighboring cantons. Differentials in local tax rates, $\nabla \ln \tau_{jkt}$, are instrumented with the corresponding differential in canton-level tax rates $\nabla \ln \tau_{cdt}$. Standard errors are clustered two-ways, at the level of origin and destination municipalities. Regressions are weighted by the log of population in 2000 of the smaller municipality in the pair.

C.3 Results

Table C1 presents a range of estimation results, beginning with OLS estimations on the full data sample and then gradually building up towards our preferred empirical model.

First, we report estimates from the panel OLS models featuring municipality and canton-year fixed effects. For the results shown in Panel A of Table C1, we use all municipalities for which housing prices are available. In Panel B, we restrict the sample to the border municipalities later retained in IV estimations. The two samples yield very similar results: a mostly negative correlation between changes in local tax rates and changes in taxpayer counts, with the magnitude of the correlation increasing with income. Similarly, local tax increases are associated with lower housing prices.

Panel C of Table C1 presents results for the cross-border spatial difference specification of equation (C2). Most of the estimated coefficients are smaller in absolute value than in Panel B, suggesting that spatial differencing controls for time-varying confounding factors that are common among proximate jurisdictions.

Instrumenting local tax differentials with canton-level tax differentials in Panel D of Table C1 does not change the estimated coefficients by much. We still find negative and statistically significant tax base elasticities for households without children and above-median income. For below-median-income households without children, we moreover observe that instrumenting turns the tax elasticity from negative to positive. This is consistent with two-way causation, whereby the arrival of such households allows municipalities to lower their tax rates as these households' (current) consumption of local public goods is below-average, but such households nonetheless prefer to move to municipalities with higher tax rates and thus more generous provision of local public goods.

Conversely, estimated tax-base and capitalization elasticities are biased towards zero to the extent that it takes time for households to move and for rental prices to adjust. In Panel E of Table C1, we therefore augment equation (C2) with two lags, themselves instrumented with the corresponding lags of the cross-border canton-level tax differentials. We report implied long-term effects and their standard errors, based on the sum of the contemporaneous and the lagged coefficients. As expected, estimated three-year tax-base and house-price capitalization elasticities are larger in absolute value than their one-year counterparts.

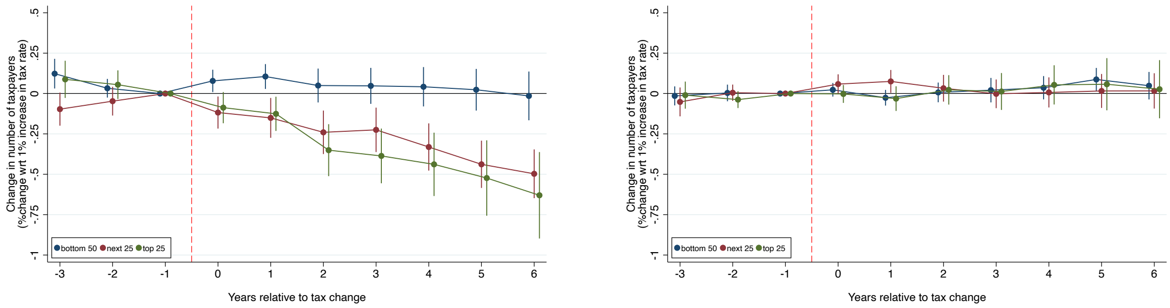
Next, we turn to the long first-differences model. Panel F of Table C1 presents estimates based on differences between the averages for 2013-2014 and 2004-2005. Results are qualitatively similar to the distributed lag model presented in Panel E, with estimated tax base elasticities of households without children and the housing price elasticity larger in the 10-year first-difference model. In Panel G, we in addition control for differences in amenities across municipalities, and, in the rental-price regressions, for differences in topographical constraints and local administrative efficiency. Estimated coefficients are not sensitive to the inclusion of these variables as controls.

Finally, we test the validity of our instrumental variable strategy, first by removing observations which might violate the exogeneity assumption, and, second, with an event-study design. A potential threat to the exogeneity of our instrument arises if capital cities are located at a cantonal border or if a large share of the population (or the tax base) of a canton is concentrated at a specific border. In Table C2 we repeat Panel G of Table C1 removing capital cities from all municipality border pairs (Panel A) and all pairs of cantons that concentrates more than 50% (Panel B) or 25% (Panel C) of the population of a canton in the pair.[4] Results are qualitatively similar to Panel G of Table C1 even in the most demanding test when the sample drops to 255 municipalities (Panel C). If anything, removing potentially influential municipalities lead to larger estimated elasticities.

Last, to address the concern of unobserved confounding factors, we exploit the panel structure of our data to explore the dynamics of the effect of our instrument over time, both before and after changes in canton-level tax rates. Building on equation (C2), we estimate the

[4]Results would not change by using the tax base instead of the population.

Figure C1: The effect of canton-level tax changes on tax bases



(a) Households without children

(b) Households with children

Notes: The figures show the cumulative effect of our instrument on the number of households without children in different income groups (upper panel) and on the number of households with children in different income groups (lower panel). It plots the sum of the coefficients and their corresponding standard errors from estimating equation (C3). Standard errors are clustered two-ways, at the level of origin and destination municipalities. Regressions are weighted by the log of population in 2000 of the smaller municipality in the pair.

following distributed lag model:

$$\nabla \ln N_{jkt}^{fm} = \sum_{n=-2}^{+6} \eta_n^{fm} \nabla \ln \tau_{cdt-n}^{fm} + \phi_{jk} + \phi_{ct} + \varepsilon_{jkt}^{fm}, \tag{C3}$$

where ϕ_{jk} are municipality-pair directional fixed effects, ϕ_{ct} is an origin canton-year fixed effect and $t \in [2004, ..., 2014]$. To estimate this model, we extend our tax rate data to the period 1998 to 2016.

Figure C1 shows the cumulative effect of canton-level tax differentials on (a) the number of households without children (in our three income groups) and (b) the number of households with children (in our three income groups). Interpreting our panel estimates as a combination of individual event studies, and as a check of the assumption of common pre-trends, we plot the sum of the coefficients and their corresponding standard errors from 3 years before a tax change (the reference year being -1) to 6 year after.[5] We find no evidence of changes in the municipality-level number of high-income and potentially mobile households in advance of canton-level tax changes. Results also show that it is above-median income households without children who move in response to tax differentials, whereas households with children do not respond statistically significantly to local tax changes. Absolute values of the estimated elasticities grow over time after the tax change, consistent with delayed mobility responses.

[5]Distributed lag models are equivalent to an event study design in which all years after $+7$ are binned together, and similarly for all years prior to -2, See Kurt Schmidheiny and Sebastian Siegloch (2023).

Table C1: Tax base and rental price elasticities: OLS and 2SLS results

	Households without children			Households with children			Housing Prices
	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fixed effect panel model							
***Panel A:* OLS estimation on all municipalities**							
Income tax rate	-0.056	-0.340***	-0.692***	0.276***	0.103	-0.228***	-0.178***
	(0.039)	(0.051)	(0.059)	(0.096)	(0.073)	(0.066)	(0.045)
# of observations	18,466	18,466	18,466	18,466	18,466	18,466	18,306
# of municipalities	1,814	1,814	1,814	1,814	1,814	1,814	1,814
Municipality fixed effect				YES			
Canton-year fixed effect				YES			
***Panel B:* OLS estimation on border municipalities**							
Income tax rate	-0.052	-0.326***	-0.685***	0.128	-0.024	-0.312***	-0.197***
	(0.055)	(0.070)	(0.084)	(0.146)	(0.099)	(0.094)	(0.056)
# of observations	8,331	8,331	8,331	8,331	8,331	8,331	8,295
# of municipalities	812	812	812	812	812	812	812
Municipality fixed effect				YES			
Canton-year fixed effect				YES			
***Panel C:* OLS pairwise difference estimation on border municipalities**							
Income tax rate	-0.029	-0.244***	-0.642***	0.032	0.060*	-0.037	-0.150***
	(0.042)	(0.059)	(0.075)	(0.023)	(0.033)	(0.054)	(0.038)
# of observations	38,830	38,830	38,830	38,830	38,830	38,830	34,540
# of municipalities	812	812	812	812	812	812	811
Municipality-pair directional fixed effect				YES			
Origin canton-year fixed effect				YES			
***Panel D:* IV pairwise difference estimation on border municipalities**							
Income tax rate	0.050	-0.199***	-0.644***	0.030	0.059*	-0.012	-0.160**
	(0.054)	(0.079)	(0.145)	(0.024)	(0.036)	(0.067)	(0.073)
# of observations	38,830	38,830	38,830	38,830	38,830	38,830	34,540
# of municipalities	812	812	812	812	812	812	811
Kleibergen-Paap F Stat	446.83	323.68	34.58	19905.74	5429.53	45.47	53.83
Municipality-pair directional fixed effect				YES			
Origin canton-year fixed effect				YES			
Instrument				Cantonal income tax rate differential			
***Panel E:* IV pairwise difference estimation on border municipalities: distributed lag model**							
Income tax rate	0.038	-0.359***	-0.960***	0.043	0.037	0.010	-0.188***
	(0.071)	(0.100)	(0.177)	(0.031)	(0.044)	(0.081)	(0.079)
# of observations	38,830	38,830	38,830	38,830	38,830	38,830	34,540
# of municipalities	812	812	812	812	812	812	811
Kleibergen-Paap F Stat	23.17	52.90	6.41	1784.98	608.20	8.56	10.11
Municipality-pair directional fixed effect				YES			
Origin canton-year fixed effect				YES			
Instrument				Cantonal income tax rate differential			
Long difference model between the averages 2013-2014 and 2004-2005							
***Panel F:* IV pairwise difference estimation on border municipalities**							
Income tax rate	0.087	-0.327**	-1.388***	0.047	0.028	-0.055	-0.390***
	(0.095)	(0.145)	(0.244)	(0.047)	(0.069)	(0.109)	(0.145)
# of observations	3,530	3,530	3,530	3,530	3,530	3,530	3,530
# of municipalities	812	812	812	812	812	812	812
Kleibergen-Paap F Stat	435.95	289.83	232.93	8023.49	4537.78	702.47	261.26
Controls				NO			
Origin canton fixed effect				YES			
Instrument				Cantonal income tax rate differential			
***Panel G:* IV pairwise difference estimation on border municipalities**							
Income tax rate	0.096	-0.338***	-1.326***	0.075	0.074	-0.080	-0.369***
	(0.095)	(0.141)	(0.250)	(0.046)	(0.068)	(0.107)	(0.153)
# of observations	3,530	3,530	3,530	3,530	3,530	3,530	3,530
# of municipalities	812	812	812	812	812	812	812
Kleibergen-Paap F Stat	450.06	297.41	238.54	8327.86	4642.86	714.32	252.56
Controls				YES			
Origin canton fixed effect				YES			
Instrument				Cantonal income tax rate differential			

Notes: Cluster robust standard errors reported in parentheses. In panels A and B, standard errors are clustered at the municipality level. In the remaining panels, standard errors are two-way clustered at origin and destination municipality level. In municipalities with zero taxpayer in a given category, ln(0) has been replaced by 0 (15 occurrences). Regressions in panel E employ a standard distributed lag approach estimating $\nabla \ln y_{jkt} = \eta^y \nabla \ln \tau_{jkt} + \sum_{s=1}^{2} \beta_s \left(\nabla \ln \tau_{jkt-s} - \nabla \ln \tau_{jkt} \right) + \phi_{jk} + \phi_{ct} + \varepsilon_{jkt}$, so that we may interpret $\hat{\eta}$ directly as the long-term effect. Controls in Panel G include (time-invariant) indices of accessibility, exposure to natural risks, architectural heritage, and hours of sunlight. In column (7) we in addition control for topographical constraints and local administrative efficiency. ***p<0.01, **p<0.05, *p<0.1.

Table C2: Tax base and rental price elasticities: robustness

	Households without children			Households with children			Housing Prices
	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
***Panel A :* Removing capital cities from border pairs**							
Income tax rate	0.085	-0.378***	-1.321***	0.078*	0.078	-0.086	-0.375***
	(0.097)	(0.145)	(0.251)	(0.047)	(0.069)	(0.110)	(0.155)
# of observations	3,454	3,454	3,454	3,454	3,454	3,454	3,454
# of municipalities	799	799	799	799	799	799	799
Kleibergen-Paap F Stat	195.16	134.68	135.38	8139.14	3972.41	402.60	131.59
Controls				YES			
Origin canton fixed effect				YES			
Instrument			Cantonal income tax rate differential				
***Panel B :* Removing canton pairs with share of cantonal population** $> 50\%$							
Income tax rate	-0.074	-0.641***	-1.667***	0.099	0.171*	-0.230	-0.307*
	(0.116)	(0.177)	(0.305)	(0.063)	(0.092)	(0.142)	(0.185)
# of observations	2,703	2,703	2,703	2,703	2,703	2,703	2,703
# of municipalities	610	610	610	610	610	610	610
Kleibergen-Paap F Stat	106.83	71.48	72.85	5738.96	2294.75	232.07	85.59
Controls				YES			
Origin canton fixed effect				YES			
Instrument			Cantonal income tax rate differential				
***Panel C :* Removing canton pairs with share of cantonal population** $> 25\%$							
Income tax rate	-0.543***	-0.876**	-2.214***	0.239	0.344*	-0.093	-0.731**
	(0.224)	(0.389)	(0.509)	(0.193)	(0.193)	(0.376)	(0.316)
# of observations	1,072	1,072	1,072	1,072	1,072	1,072	1,072
# of municipalities	255	255	255	255	255	255	255
Kleibergen-Paap F Stat	205.62	127.91	48.73	1264.04	1393.90	39.00	73.34
Controls				YES			
Origin canton fixed effect				YES			
Instrument			Cantonal income tax rate differential				

Notes: Cluster robust standard errors reported in parentheses. Standard errors are two-way clustered at origin and destination municipality level. In municipalities with zero taxpayer in a given category, $\ln(0)$ has been replaced by 0. Controls include (time-invariant) indices of accessibility, exposure to natural risks, architectural heritage, and hours of sunlight. In column (7) we in addition control for topographical constraints and local administrative efficiency. In Panel A, we remove capital cities/towns from the municipality border pairs. In Panel B and Panel C we drop pairs of cantons that contain more than 50% and 25%, respectively, of the population of a canton in the pair. ***p<0.01, **p<0.05, *p<0.1.

D Supplementary tables

Table D1: Structural parameter and elasticity estimates for different values of $\eta^{s,p}$ and θ

	Households without children			Households with children		
	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: $\eta^{s,p} = 0$						
Preference for public goods (δ)		-0.010			0.161	
		(0.023)			(0.178)	
Idiosyncratic location preference dispersion parameter (λ)		6.062			0.341	
		(0.457)			(0.191)	
Tax base elasticities	0.200	-0.329	-0.849	0.093	0.059	0.024
	(0.038)	(0.037)	(0.057)	(0.017)	(0.017)	(0.033)
Marginal willingness to pay rent	-0.327	-0.553	-0.956	0.097	0.087	-0.125
	(0.032)	(0.052)	(0.070)	(0.243)	(0.374)	(0.500)
Resident incidence	0.033	-0.054	-0.140	0.272	0.173	0.072
	(0.004)	(0.008)	(0.010)	(0.130)	(0.132)	(0.133)
Landlord incidence ($\eta^{p,\tau*}$)			-0.389			
			(0.030)			
Panel B: $\eta^{s,p} = 1$						
Preference for public goods (δ)		0.128			0.128	
		(0.009)			(0.059)	
Idiosyncratic location preference dispersion parameter (λ)		11.350			0.760	
		(0.708)			(0.297)	
Tax base elasticities	0.165	-0.320	-1.091	0.090	0.047	-0.015
	(0.037)	(0.040)	(0.067)	(0.017)	(0.017)	(0.036)
Marginal willingness to pay rent	-0.146	-0.259	-0.563	0.038	-0.004	-0.246
	(0.015)	(0.024)	(0.032)	(0.075)	(0.116)	(0.155)
Resident incidence	0.015	-0.028	-0.096	0.118	0.062	-0.020
	(0.003)	(0.004)	(0.005)	(0.039)	(0.040)	(0.040)
Landlord incidence ($\eta^{p,\tau*}$)			-0.173			
			(0.012)			
Panel C: $\theta = 0$						
Preference for public goods (δ)		0.058			0.122	
		(0.016)			(0.099)	
Idiosyncratic location preference dispersion parameter (λ)		8.106			0.528	
		(0.552)			(0.233)	
Tax base elasticities	0.182	-0.344	-0.967	0.091	0.050	0.002
	(0.038)	(0.040)	(0.062)	(0.017)	(0.017)	(0.034)
Marginal willingness to pay rent	-0.239	-0.410	-0.764	0.027	-0.021	-0.269
	(0.023)	(0.038)	(0.050)	(0.122)	(0.188)	(0.252)
Resident incidence	0.022	-0.042	-0.119	0.172	0.095	0.003
	(0.003)	(0.006)	(0.008)	(0.063)	(0.065)	(0.066)
Landlord incidence ($\eta^{p,\tau*}$)			-0.281			
			(0.021)			
Panel D: $\theta = 1$						
Preference for public goods (δ)		0.051			0.108	
		(0.016)			(0.089)	
Idiosyncratic location preference dispersion parameter (λ)		8.106			0.528	
		(0.552)			(0.233)	
Tax base elasticities	0.182	-0.344	-0.967	0.091	0.050	0.002
	(0.038)	(0.040)	(0.062)	(0.017)	(0.017)	(0.034)
Marginal willingness to pay rent	-0.239	-0.410	-0.764	0.027	-0.021	-0.269
	(0.023)	(0.038)	(0.050)	(0.122)	(0.188)	(0.252)
Resident incidence	0.022	-0.042	-0.119	0.172	0.095	0.003
	(0.003)	(0.006)	(0.008)	(0.063)	(0.065)	(0.066)
Landlord incidence ($\eta^{p,\tau*}$)			-0.281			
			(0.021)			

Table D2: Tax base elasticities for households without children: pensioners and non-pensioners

	Households without children					
	Non-pensioners			Pensioners		
	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25
	(1)	(2)	(3)	(4)	(5)	(6)
Fixed effect panel model						
***Panel A:* OLS estimation on all municipalities**						
Income tax rate	-0.073	-0.398***	-0.733***	0.029	-0.128	-0.576***
	(0.049)	(0.068)	(0.069)	(0.112)	(0.156)	(0.176)
# of observations	17,636	17,636	17,636	17,636	17,636	17,636
# of municipalities	1,814	1,814	1,814	1,814	1,814	1,814
Municipality fixed effect	YES					
Canton-year fixed effect	YES					
***Panel B:* OLS estimation on border municipalities**						
Income tax rate	-0.083	-0.368***	-0.657***	0.137	0.028	-0.428
	(0.073)	(0.090)	(0.101)	(0.194)	(0.296)	(0.322)
# of observations	8,082	8,082	8,082	8,082	8,082	8,082
# of municipalities	812	812	812	812	812	812
Municipality fixed effect	YES					
Canton-year fixed effect	YES					
***Panel C:* OLS pairwise difference estimation on border municipalities**						
Income tax rate	-0.042	-0.309***	-0.869***	0.172***	-0.179**	-0.284**
	(0.044)	(0.080)	(0.101)	(0.062)	(0.083)	(0.128)
# of observations	36,216	36,216	36,216	36,188	36,188	36,188
# of municipalities	812	812	812	812	812	812
Municipality-pair directional fixed effect	YES					
Origin canton-year fixed effect	YES					
***Panel D:* IV pairwise difference estimation on border municipalities**						
Income tax rate	0.061	-0.276***	-1.010***	0.144**	-0.280***	-0.271*
	(0.070)	(0.114)	(0.184)	(0.067)	(0.099)	(0.158)
# of observations	36,216	36,216	36,216	36,188	36,188	36,188
# of municipalities	812	812	812	812	812	812
Kleibergen-Paap F Stat	335.59	256.16	79.29	5036.15	1955.66	193.39
Municipality-pair directional fixed effect	YES					
Origin canton-year fixed effect	YES					
Instrument	Cantonal income tax rate differential					
***Panel E:* IV pairwise difference estimation on border municipalities: distributed lag model**						
Income tax rate	0.238**	-0.505***	-1.402***	0.062	-0.373***	-0.414**
	(0.107)	(0.166)	(0.244)	(0.073)	(0.120)	(0.189)
# of observations	36,216	36,216	36,216	36,188	36,188	36,188
# of municipalities	812	812	812	812	812	812
Kleibergen-Paap F Stat	12.71	54.05	8.45	545.80	281.99	16.79
Municipality-pair directional fixed effect	YES					
Origin canton-year fixed effect	YES					
Instrument	Cantonal income tax rate differential					
Long difference model between the averages 2013-2014 and 2004-2005						
***Panel F:* IV pairwise difference estimation on border municipalities**						
Income tax rate	0.295**	-0.526**	-1.779***	0.226***	-0.388***	-0.438**
	(0.148)	(0.246)	(0.315)	(0.084)	(0.134)	(0.220)
# of observations	3,526	3,526	3,526	3,526	3,526	3,526
# of municipalities	811	811	811	811	811	811
Kleibergen-Paap F Stat	201.83	156.78	241.58	8973.85	2543.47	1435.84
Controls	NO					
Origin canton fixed effect	YES					
Instrument	Cantonal income tax rate differential					
***Panel G:* IV pairwise difference estimation on border municipalities**						
Income tax rate	0.349**	-0.521**	-1.729***	0.223***	-0.386***	-0.414*
	(0.154)	(0.252)	(0.324)	(0.084)	(0.130)	(0.220)
# of observations	3,526	3,526	3,526	3,526	3,526	3,526
# of municipalities	811	811	811	811	811	811
Kleibergen-Paap F Stat	201.83	156.78	241.58	8973.85	2543.47	1435.84
Controls	YES					
Origin canton fixed effect	YES					
Instrument	Cantonal income tax rate differential					

Notes: Cluster robust standard errors reported in parentheses. In panels A and B, standard errors are clustered at the municipality level. In the remaining panels, standard errors are two-way clustered at origin and destination municipality level. In municipalities with zero taxpayer in a given category, $\ln(0)$ has been replaced by 0. Regressions in panel E employ a standard distributed lag approach estimating $\nabla \ln y_{jkt} = \eta^y \nabla \ln \tau_{jkt} + \sum_{s=1}^{2} \beta_s \left(\nabla \ln \tau_{jkt-s} - \nabla \ln \tau_{jkt} \right) + \phi_{jk} + \phi_{ct} + \varepsilon_{jkt}$, so that we may interpret $\hat{\eta}$ directly as the long-term effect. Controls in panel G include (time-invariant) indices of accessibility, exposure to natural risks, architectural heritage, and hours of sunlight. ***p<0.01, **p<0.05, *p<0.1.

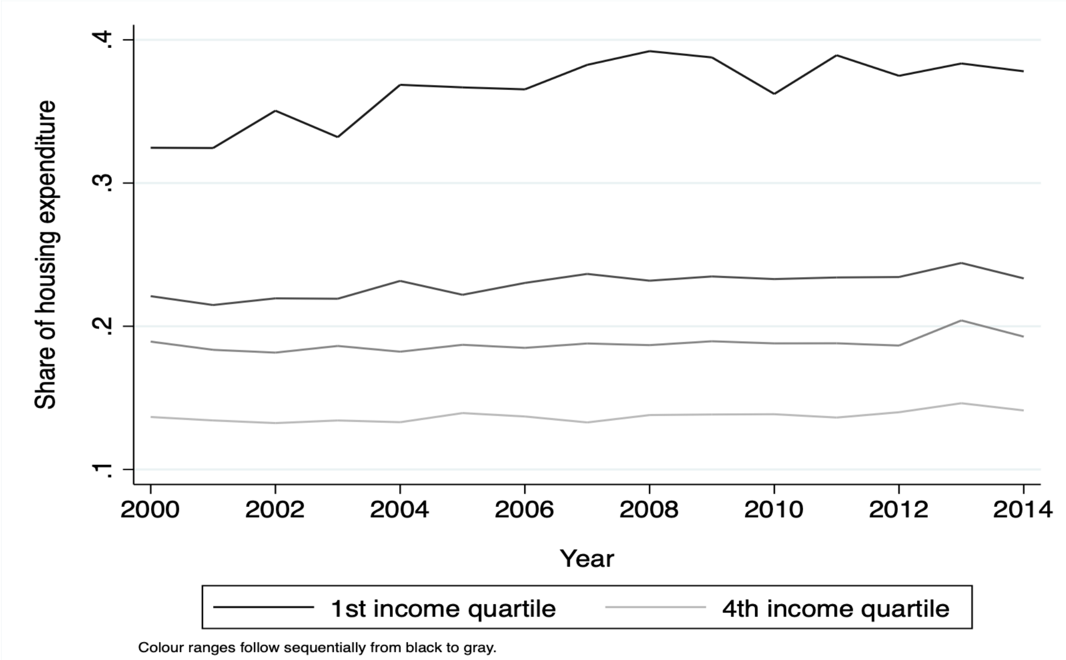
Table D3: Structural parameter and elasticity estimates: pensioners and non-pensioners

	Households without children						Households with children		
	Non-pensioners			Pensioners					
	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25	Bottom 50	Next 25	Top 25
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
***Panel A:* Calibration using:**									
Swiss Household Panel									
Housing tastes (α)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Minimal housing expenditure (ν_h/h^*)	0.72	0.55	0.39	0.72	0.51	0.36	0.74	0.59	0.44
Expenditure share on housing (S)	0.37	0.23	0.16	0.40	0.24	0.17	0.37	0.25	0.18
Aggregate housing share (π)	0.09	0.10	0.12	0.09	0.11	0.12	0.11	0.12	0.14
Tax Rate Database									
Income tax rates (τ)	0.12	0.14	0.18	0.09	0.11	0.16	0.05	0.07	0.12
Simultaneous equation IV estimates (Table B2)									
Housing supply price elasticity (η_s)					0.32				
Tax Base Database									
Taxpayer population share (s)	0.29	0.11	0.09	0.14	0.06	0.03	0.06	0.09	0.12
Share of tax base (γ)	0.12	0.13	0.23	0.06	0.05	0.07	0.02	0.07	0.25
Other parameter									
Congestion parameter (θ)					0.50				
***Panel B:* Structural parameters**									
Preference for public goods ($\bar{\delta}$)		0.049			0.026			0.076	
		(0.018)			(0.020)			(0.091)	
Idiosyncratic location preference dispersion parameter (λ)		11.474			4.635			0.522	
		(0.799)			(0.401)			(0.210)	
***Panel C:* Structural elasticities**									
Tax base elasticities	0.334	-0.485	-1.405	0.245	-0.123	-0.480	0.089	0.042	-0.009
	(0.060)	(0.055)	(0.086)	(0.026)	(0.042)	(0.067)	(0.017)	(0.017)	(0.034)
Marginal willingness to pay rent	-0.286	-0.472	-0.856	-0.239	-0.432	-0.797	-0.032	-0.115	-0.406
	(0.024)	(0.038)	(0.052)	(0.026)	(0.046)	(0.059)	(0.110)	(0.171)	(0.232)
Resident incidence	0.029	-0.042	-0.122	0.053	-0.027	-0.104	0.171	0.081	-0.016
	(0.004)	(0.006)	(0.008)	(0.006)	(0.008)	(0.009)	(0.057)	(0.058)	(0.059)
Landlord incidence ($\eta^{p,\tau*}$)					-0.343				
					(0.022)				

Notes: Standard errors reported in parentheses.

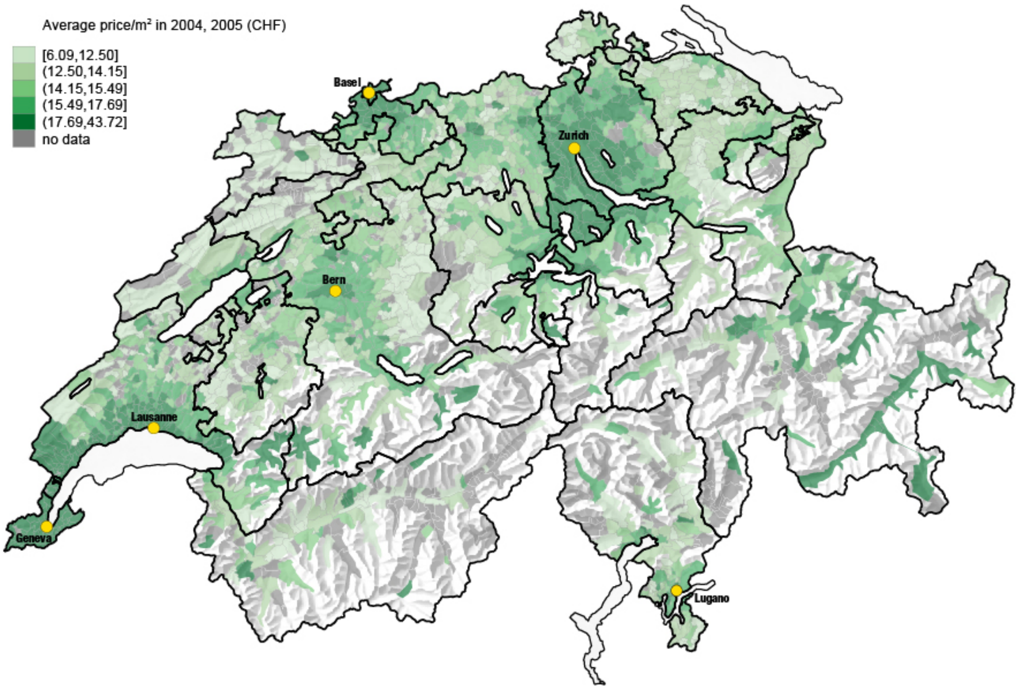
E Supplementary figures

Figure E1: Expenditure shares on housing

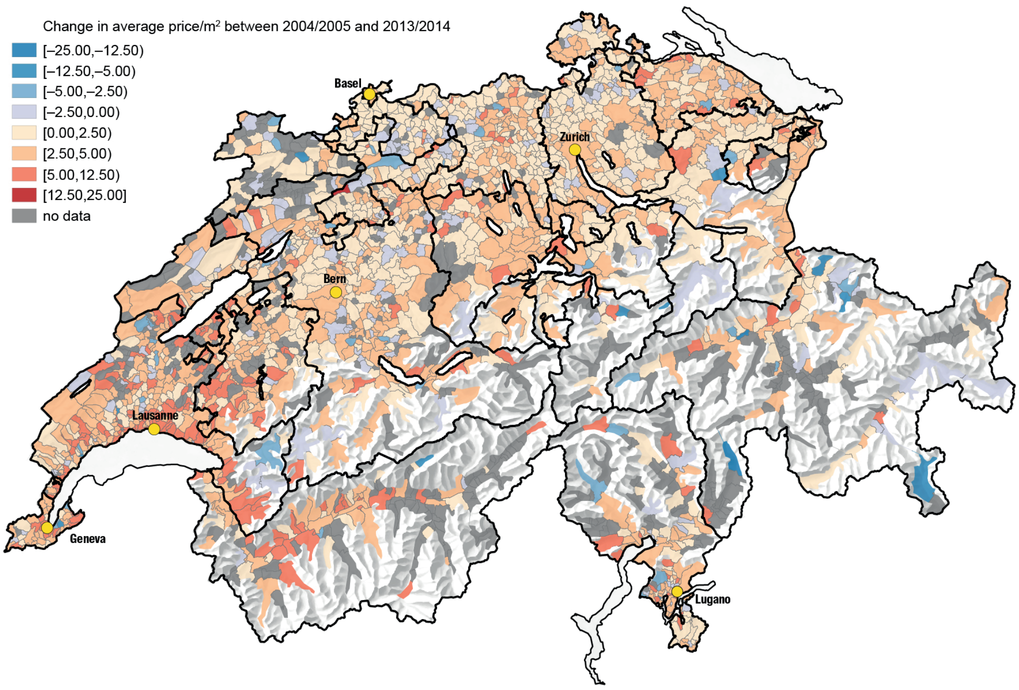


Notes: This figure reports the evolution of housing expenditure shares (defined as annual rent over disposable income) by income quartile. Source: Swiss Household Panel data.

Figure E2: The geography of housing prices in Switzerland



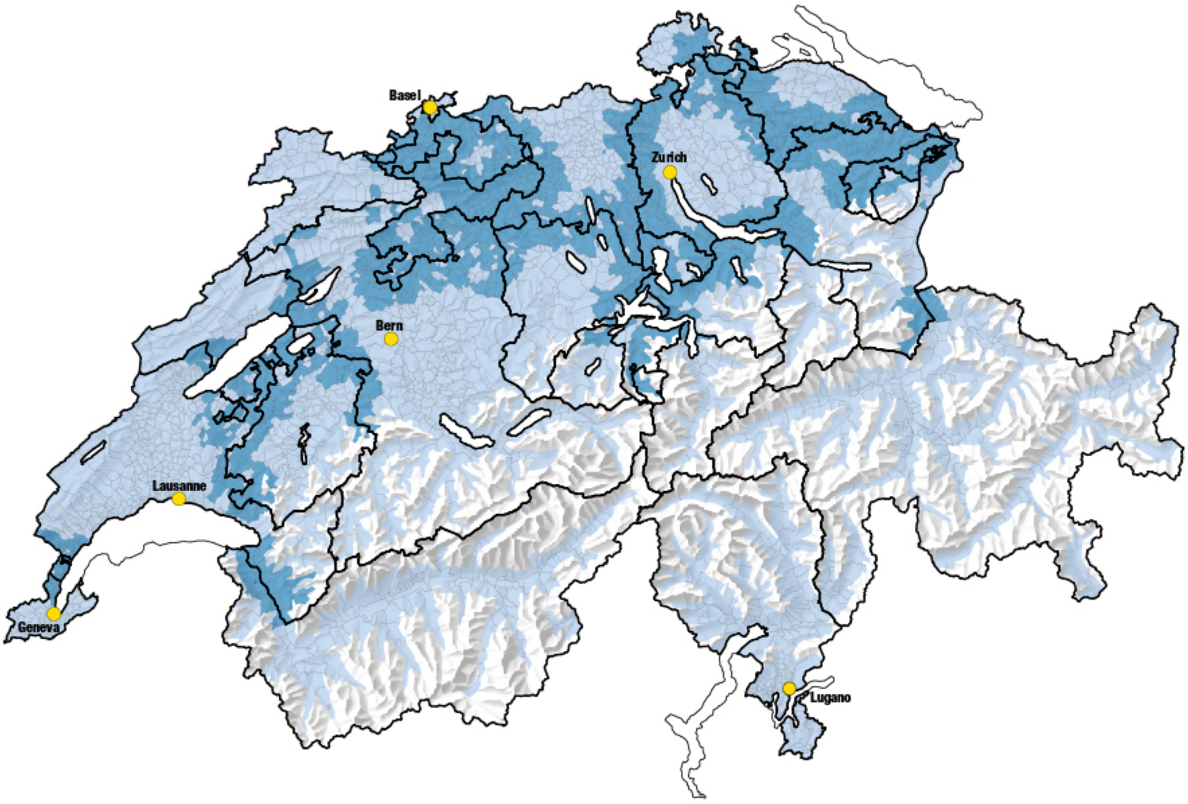
(a)



(b)

Notes: Panel (a) depicts the average rental prices in CHF per square meter, for the initial years 2004 and 2005. Panel (b) represents the difference in rental prices between the average of 2004, 2005 and 2013, 2014. The averages over the initial and final period serve to ensure the largest sample of municipalities. The white lines represent municipal administrative borders. The black lines represent cantonal administrative borders.

Figure E3: IV estimation sample at cantonal borders



Notes: Black lines are cantonal borders. Dark blue municipalities used in the instrumental variable estimations. They are selected using a 10km road distance criteria between municipality population centroids.

F Technical derivations

This section contains the detailed derivations of our baseline model. In Subsection F.1, we characterize the individual's marginal willingness to pay rent (MWPR) for a small tax change. In Subsection F.2, we derive our system of equations characterizing the effect of a small change in the tax rate on the equilibrium number of residents in different income classes and on equilibrium housing prices. In Subsection F.3, we derive the incidence of a change in the tax rate on residents' and landlords' welfare.

F.1 The marginal willingness to pay rent (MWPR)

The optimization problem of household i of type $\{f, m\}$ and residing in location j can be written as follows:

$$\max_{h_{fmj}, z_{fmj}} U_{ifmj} = \alpha \ln(h_{fmj} - \nu_h^f) + (1-\alpha)\ln(z_{fmj} - \nu_z^f) + \delta \ln(g_j - \nu_g^f) + \ln(A_{ifj})$$
$$\text{s.t.} \quad z_{fmj} + p_j h_{fmj} = (1-\tau_j) w_m \,. \tag{F1}$$

The individual Marshallian demands of this program are

$$h^*_{fmj} = \nu_h^f + \frac{\alpha \left[(1-\tau_j)w_m - p_j \nu_h^f - \nu_z^f\right]}{p_j}\,, \text{and} \tag{F2}$$
$$z^*_{fmj} = \nu_z^f + (1-\alpha)\left[(1-\tau_j)w_m - p_j \nu_h^f - \nu_z^f\right]\,, \tag{F3}$$

where $\nu_h^f \geq 0$, $\nu_z^f \geq 0$ and $\nu_g^f \geq 0$ can be thought of, respectively, as existential needs for housing, the non-housing composite good and the public good, which may differ depending on family status. For simplicity, and without loss of generality, we assume $\nu_z^f = 0$. Unlike with a standard Cobb-Douglas utility, the elasticity of individual housing demand with respect to prices is not constant. It is given by

$$\left|\frac{\partial h^*_{fmj}}{\partial p_j}\frac{p_j}{h^*_{fmj}}\right| = 1 - \frac{(1-\alpha)\nu_h^f}{h^*_{fmj}}\,,$$

which is equal to one only if $\nu_h^f = 0$ and less than one otherwise.

It is also useful to rewrite the individual Marshallian demand for housing space (F2) as fraction of income spent on housing

$$S_{fmj} = (1-\alpha) S^{min}_{fmj} + \alpha\,, \tag{F4}$$

where $S_{fmj} \equiv p_j h^*_{fmj}/(1-\tau_j)w_m$ is the fraction of income spend on housing consumption and $S^{min}_{fmj} \equiv p_j \nu^f/(1-\tau_j)w_m$ is the fraction of income spent on minimum housing consumption.

The household's indirect utility, given its choice of location j, is

$$V_{ifmj} = \kappa + \ln\left[(1-\tau_j)w_m - p_j\nu_h^f\right] - \alpha\ln(p_j) + \delta\ln(g_j - \nu_g^f) + \ln(A_{ifj}), \tag{F5}$$

where $\kappa = \alpha\ln(\alpha) + (1-\alpha)\ln(1-\alpha)$.

We define as marginal willingness to pay rent the change in the housing price ('bid-rent' price change) a household of type $\{f, m\}$ would require to be indifferent toward a given change in the local tax rate:

$$\begin{aligned}
dV_{ifmj} &= \left[\frac{\partial V_{ifmj}}{\partial p_j}dp_j + \frac{\partial V_{ifmj}}{\partial \tau_j}d\tau_j + \frac{\partial V_{ifmj}}{\partial g_j}dg_j\right] \\
dV_{ifmj} &= \left[-\alpha\left(\frac{h^*_{fmj}}{h^*_{fmj}-\nu_h^f}\right)\frac{dp_j}{p_j} - \alpha\frac{\tau_j}{(1-\tau_j)S_{fmj}}\left(\frac{h^*_{fmj}}{h^*_{fmj}-\nu_h^f}\right)\frac{d\tau_j}{\tau_j} + \delta\left(\frac{g_j}{g_j-\nu_g^f}\right)\frac{dg_j}{g_j}\right] \\
dV_{ifmj} &= \alpha\left(\frac{h^*_{fmj}}{h^*_{fmj}-\nu_h^f}\right)\left[-\frac{dp_j}{p_j} - \frac{\tau_j}{(1-\tau_j)S_{fmj}}\frac{d\tau_j}{\tau_j} + \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right)\frac{dg_j}{g_j}\right].
\end{aligned}$$

Hence,

$$\left.\frac{dp_j}{d\tau_j}\frac{\tau_j}{p_j}\right|_{dV_{ifmj}=0} = -\left[\frac{\tau_j}{(1-\tau_j)S_{fmj}} - \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right)\frac{dg_j}{d\tau_j}\frac{\tau_j}{g_j}\right], \tag{F6}$$

where

$$\frac{dg_j}{d\tau_j}\frac{\tau_j}{g_j} = 1 + \sum_f\sum_m(\gamma_{fmj} - \theta s_{fmj})\frac{dN_{fmj}}{N_{fmj}}\frac{\tau_j}{d\tau_j}, \tag{F7}$$

with $\gamma_{fmj} \equiv w_m N_{fmj}/\sum_f\sum_m w_m N_{fmj}$ and $s_{fmj} \equiv N_{fmj}/N_j$.

F.2 Equilibrium

The model's equilibrium is characterized by three main equations:

$$N_j = \sum_f\sum_m N_{fmj} \text{ with } N_{fmj} = \frac{\exp(\lambda_f u_{fmj})}{\sum_{j'}\exp(\lambda_f u_{fmj'})} \quad \forall j \in J, \tag{F8a}$$

$$H_j^d = H_j^s \text{ with } H_j^d = \sum_f\sum_m N_{fmj}\cdot h^*_{fmj} \text{ and } H_j^s = B_j p_j^{\eta_j^{s,p}} \quad \forall j \in J, \tag{F8b}$$

$$g_j = \tau_j N_j^{-\theta}\sum_f\sum_m w_m N_{fmj} \quad \forall j \in J, \tag{F8c}$$

where (F8a) describes the population, (F8b) governs the housing market, and (F8c) is the government budget constraint for each jurisdiction j.

Totally log-differentiating equation (F8c) and using the notation $\dot{x} = dx/x$ yields:

$$
\begin{aligned}
d\ln g_j &= \frac{\partial \ln g_j}{\partial \tau_j} d\tau_j + \sum_f \sum_m \frac{\partial \ln g_j}{\partial N_{fmj}} dN_{fmj} - \theta \sum_f \sum_m \frac{\partial \ln g_j}{\partial N_{fmj}} dN_{fmj} \\
\frac{dg_j}{g_j} &= \frac{d\tau_j}{\tau_j} + \sum_f \sum_m \frac{w_m dN_{fmj}}{\sum_f \sum_m w_m N_{fmj}} - \theta \sum_f \sum_m \frac{N_{fmj}}{N_j} \frac{dN_{fmj}}{N_{fmj}} \\
\dot{g}_j &= \dot{\tau}_j + \sum_f \sum_m \gamma_{fmj} \dot{N}_{fmj} - \sum_f \sum_m \theta s_{fmj} \dot{N}_{fmj} \\
\dot{g}_j &= \dot{\tau}_j + \sum_f \sum_m (\gamma_{fmj} - \theta s_{fmj}) \dot{N}_{fmj} \,.
\end{aligned}
$$

Totally log-differentiating equation (F8b) yields:

$$
\begin{aligned}
dH_j^d &= dH_j^s \\
\sum_f \sum_m \left[\frac{\partial H^d_{fmj}}{\partial N_{fmj}} dN_{fmj} + N_{fmj} \frac{\partial h^*_{fmj}}{\partial p_j} dp_j + N_{fmj} \frac{\partial h^*_{fmj}}{\partial \tau_j} d\tau_j \right] &= \frac{\partial H_j^s}{\partial p_j} dp_j \\
\sum_f \sum_m \left[H^d_{fmj} \dot{N}_{fmj} + H^d_{fmj} \underbrace{\left(\frac{\partial h^*_{fmj}}{\partial p_j} \frac{p_j}{h^*_{fmj}} \right)}_{-1+(1-\alpha)\frac{\nu_h^f}{h^*_{fmj}}} \dot{p}_j + H^d_{fmj} \underbrace{\left(\frac{\partial h^*_{fmj}}{\partial \tau_j} \frac{\tau_j}{h^*_{fmj}} \right)}_{-\frac{\alpha}{S_{fmj}} \frac{\tau_j}{(1-\tau_j)}} \dot{\tau}_j \right] \frac{1}{H_j^d} &= \eta_j^{s,p} \dot{p}_j \\
\sum_f \sum_m \pi_{fmj} \dot{N}_{fmj} - \left(\rho_j + \eta_j^{s,p} \right) \dot{p}_j &= \alpha \frac{\tau_j}{(1-\tau_j)} \sum_f \sum_m \dot{\tau}_j \frac{\pi_{fmj}}{S_{fmj}} \,,
\end{aligned}
$$

where $\pi_{fmj} \equiv H^d_{fmj} / H^d_j$ is household type $\{f, m\}$'s share of aggregate housing demand, and $\rho_j \equiv \sum_f \sum_m \pi_{fmj}(1 - (1-\alpha)\frac{\nu_h^f}{h^*_{fmj}})$ collects other parameters.

Finally, totally log-differentiating equation (F8a) for a given municipality j and household type $\{f, m\}$, yields:

$$
\begin{aligned}
dN_{fmj} &= \lambda_f N_{fmj} \left[\frac{\partial V_{ifmj}}{\partial p_j} dp_j + \frac{\partial V_{ifmj}}{\partial \tau_j} d\tau_j + \frac{\partial V_{ifmj}}{\partial g_j} dg_j \right] \\
\frac{1}{\lambda_f} \dot{N}_{fmj} &= -\alpha \left(\frac{h^*_{fmj}}{h^*_{fmj} - \nu_h^f} \right) \dot{p}_j - \frac{\alpha \tau_j}{(1-\tau_j) S_{fmj}} \left(\frac{h^*_{fmj}}{h^*_{fmj} - \nu_h} \right) \dot{\tau}_j + \delta \left(\frac{g_j}{g_j - \nu_g^f} \right) \dot{g}_j \\
\frac{1}{\alpha \lambda_f} \left(1 - \frac{\nu_h^f}{h^*_{fmj}} \right) \dot{N}_{fmj} + \dot{p}_j &= -\frac{\tau_j}{(1-\tau_j) S_{fmj}} \dot{\tau}_j + \frac{\delta}{\alpha} \left(\frac{g_j}{g_j - \nu_g^f} \right) \left(1 - \frac{\nu_h^f}{h^*_{fmj}} \right) \left[\dot{\tau}_j + \sum_f \sum_m (\gamma_{fmj} - \theta s_{fmj}) \dot{N}_{fmj} \right] \\
\frac{1 - \delta \left(\frac{g_j}{g_j - \nu_g^f} \right) (\gamma_{fmj} - \theta s_{fmj}) \lambda_f}{\alpha \lambda_f} \left(1 - \frac{\nu_h^f}{h^*_{fmj}} \right) \dot{N}_{fmj} - \mathcal{O} + \dot{p}_j &= \left[\frac{\delta}{\alpha} \left(\frac{g_j}{g_j - \nu_g^f} \right) \left(1 - \frac{\nu_h^f}{h^*_{fmj}} \right) - \frac{\tau_j}{(1-\tau_j) S_{fmj}} \right] \dot{\tau}_j
\end{aligned}
$$

where $\mathcal{O} \equiv \frac{\delta}{\alpha} \left(\frac{g_j}{g_j - \nu_g^f} \right) \left(1 - \frac{\nu_h^f}{h^*_{fmj}} \right) \sum_{f' \neq f} \sum_{m' \neq m} (\gamma_{f'm'j} - \theta s_{f'm'j}) \dot{N}_{f'm'j}$.

Stacking the $\mathcal{F} \times \mathcal{M}$ population equations and the equilibrium rental price solution into a system of equations yields

$$\mathbf{A_j}\dot{\mathbf{y}}_\mathbf{j} = \mathbf{B_j}\dot{\tau}_j\,, \tag{F9}$$

where

$$\mathbf{A_j} = \begin{bmatrix} \frac{1-\delta\left(\frac{g_j}{g_j-\nu_g^1}\right)(\gamma_{11j}-\theta s_{11j})\lambda_1}{\alpha\lambda_1}\left(1-\frac{\nu_h^1}{h_{11j}^*}\right) & -\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)(\gamma_{12j}-\theta s_{12j})\left(1-\frac{\nu_h^1}{h_{11j}^*}\right) & \cdots & -\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)(\gamma_{\mathcal{FM}j}-\theta s_{\mathcal{FM}j})\left(1-\frac{\nu_h^1}{h_{11j}^*}\right) & 1 \\ -\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)(\gamma_{11j}-\theta s_{11j})\left(1-\frac{\nu_h^1}{h_{12j}^*}\right) & \frac{1-\delta\left(\frac{g_j}{g_j-\nu_g^1}\right)(\gamma_{12j}-\theta s_{12j})\lambda_1}{\alpha\lambda_1}\left(1-\frac{\nu_h^1}{h_{12j}^*}\right) & \vdots & \vdots & \vdots \\ \vdots & \cdots & \ddots & \vdots & \vdots \\ -\delta\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)(\gamma_{\mathcal{F}1j}-\theta s_{\mathcal{F}1j})\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right) & \cdots & \cdots & \frac{1-\delta\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)(\gamma_{\mathcal{FM}j}-\theta s_{\mathcal{FM}j})\lambda_{\mathcal{F}}}{\alpha\lambda_{\mathcal{F}}}\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right) & 1 \\ \pi_{11j} & \cdots & \cdots & \pi_{\mathcal{FM}j} & -\left(\rho_j+\eta_j^{s,p}\right) \end{bmatrix}$$

and

$$\mathbf{B_j} = \begin{bmatrix} \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{11j}^*}\right)-\frac{\tau_j}{(1-\tau_j)S_{11j}} \\ \vdots \\ \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right)-\frac{\tau_j}{(1-\tau_j)S_{\mathcal{FM}j}} \\ \alpha\frac{\tau_j}{(1-\tau_j)}\sum_f\sum_m\frac{\pi_{fmj}}{S_{fmj}} \end{bmatrix}.$$

F.3 Incidence

Overall renter household welfare is given by

$$\mathcal{W}^R = \sum_f\sum_m s_{fm}\cdot\frac{1}{\lambda_f}\log\left(\sum_j\exp(\lambda_f u_{fmj})\right).$$

The effect of a change in the tax rate of municipality j on the welfare of household type $\{f, m\}$, abstracting from general equilibrium effects on other jurisdictions, is given by

$$\begin{aligned}
d\mathcal{W}_{fm}^R &= N_{fmj}\left[\frac{\partial u_{fmj}}{\partial p_j}dp_j+\frac{\partial u_{fmj}}{\partial\tau_j}d\tau_j+\frac{\partial u_{fmj}}{\partial g_j}dg_j\right] \\
d\mathcal{W}_{fm}^R &= \alpha N_{fmj}\left[-\left(\frac{h_{fmj}^*}{h_{fmj}^*-\nu_h^f}\right)\frac{dp_j}{p_j}-\frac{\tau_j}{(1-\tau_j)S_{fmj}}\left(\frac{h_{fmj}^*}{h_{fmj}^*-\nu_h^f}\right)\frac{d\tau_j}{\tau_j}+\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\frac{dg_j}{g_j}\right] \\
\frac{d\mathcal{W}_{fm}^R}{d\ln\tau_j} &= \alpha N_{fmj}\left\{\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(\frac{dg_j}{d\tau_j}\frac{\tau_j}{g_j}\right)-\frac{\tau_j}{(1-\tau_j)S_{fmj}}\left(\frac{h_{fmj}^*}{h_{fmj}^*-\nu_h^f}\right)-\left(\frac{h_{fmj}^*}{h_{fmj}^*-\nu_h^f}\right)\left(\frac{dp_j^*}{d\tau_j}\frac{\tau_j}{p_j^*}\right)\right\} \\
\frac{d\mathcal{W}_{fm}^R}{d\ln\tau_j} &= \alpha N_{fmj}\left(1-\frac{\nu_h^f}{h_{fmj}}\right)^{-1}\left\{\underbrace{-\left[\frac{\tau_j}{(1-\tau_j)S_{fmj}}-\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h_{fmj}}\right)\left(\frac{dg_j}{d\tau_j}\frac{\tau_j}{g_j}\right)\right]}_{\text{MWPR}_{fm}}-\underbrace{\left(\frac{dp_j^*}{d\tau_j}\frac{\tau_j}{p_j^*}\right)}_{\eta^{p,\tau*}}\right\},
\end{aligned} \tag{F10}$$

where $\eta^{p,\tau*}$ is the observed change in the equilibrium housing price. The overall change in household welfare is then $\frac{d\mathcal{W}^R}{d\ln\tau_j} = \sum_f\sum_m s_{fm}\cdot\frac{d\mathcal{W}_{fm}^R}{d\ln\tau_j}$.

Note that $\left(1-\frac{\nu_h^f}{h_{fmj}}\right) = \left(1-\frac{S_{fmj}^{min}}{S_{fmj}}\right)$, and by using (F4), one can rewrite equation (F10) as

$$\frac{d\mathcal{W}^R_{fm}}{d\ln\tau_j} = N_{fmj}\left\{-\frac{\tau_j}{(1-\tau_j)}\left(\frac{1}{1-S^{min}_{fmj}}\right)+\delta\left(\frac{g_j}{g_j-\nu^f_g}\right)\left(\frac{dg_j}{d\tau_j}\frac{\tau_j}{g_j}\right)-\left(\frac{S_{fmj}}{1-S^{min}_{fmj}}\right)\left(\frac{dp^*_j}{d\tau_j}\frac{\tau_j}{p^*_j}\right)\right\}. \tag{F11}$$

The producer surplus is given by

$$\mathcal{W}^L = \int_0^{H^*}\left(p^*_j - \left(\frac{x}{B_j}\right)^{1/\eta^{s,p}}\right)dx = \frac{p^*H^*}{(1+\eta^{s,p})}.$$

The change in the landlord's welfare after a change in the local tax is then

$$\begin{aligned}
d\mathcal{W}^L &= \left(\frac{1}{1+\eta^{s,p}}\right)\left(\frac{\partial\mathcal{W}^L}{\partial p^*_j}dp^*_j + \frac{\partial\mathcal{W}^L}{\partial H^*_j}dH^*_j\right)\\
d\mathcal{W}^L &= \left(\frac{1}{1+\eta^{s,p}}\right)\left(H^*_j dp^*_j + p^*_j dH^*_j\right)\\
\frac{d\mathcal{W}^L}{d\tau_j}\tau_j &= \left(\frac{p^*_jH^*_j}{1+\eta^{s,p}}\right)\left(\left(\frac{dp^*_j}{d\tau_j}\frac{\tau_j}{p^*_j}\right)+\left(\frac{dp^*_j}{d\tau_j}\frac{\tau_j}{p^*_j}\right)\left(\frac{dH^*_j}{dp^*_j}\frac{p^*_j}{H^*_j}\right)\right)\\
\frac{d\mathcal{W}^L}{d\ln\tau_j} &= p^*_jH^*_j\underbrace{\left(\frac{dp^*_j}{d\tau_j}\frac{\tau_j}{p^*_j}\right)}_{\eta^{p,\tau*}}. \qquad \text{(F12)}
\end{aligned}$$

As a result, landlords' welfare is fully determined by changes in equilibrium rental prices.

G A model with property taxes

Here, we show the derivations of a variant of our model in which local governments levy a local property tax t on rental prices, instead of an income tax.

The optimization problem of household i of type $\{f, m\}$ and residing in location j can be written as:

$$\begin{aligned}
\max_{h_{fmj}, z_{fmj}} \; & U_{ifmj} = \alpha\ln(h_{fmj}-\nu^f_h) + (1-\alpha)\ln(z_{fmj}-\nu^f_z) + \delta\ln(g_j-\nu^f_g) + \ln(A_{ifj})\\
\text{s.t.} \quad & z_{fmj} + (1+t_j)p_jh_{fmj} = w_m. \qquad \text{(G1)}
\end{aligned}$$

The individual Marshallian demands of this program are

$$h^*_{fmj} = \nu^f_h + \frac{\alpha\left[w_m-(1+t_j)p_j\nu^f_h-\nu^f_z\right]}{(1+t_j)p_j}, \text{and} \tag{G2}$$

$$z^*_{fmj} = \nu^f_z + (1-\alpha)\left[w_m-(1+t_j)p_j\nu^f_h-\nu^f_z\right]. \tag{G3}$$

For simplicity, and without loss of generality, we assume $\nu_z^f = 0$. The household's indirect utility, given its choice of location j, is

$$V_{ifmj} = \underbrace{\kappa + \ln\left[w_m - (1+t_j)p_j\nu_h^f\right] - \alpha\ln((1+t_j)p_j) + \delta\ln(g_j - \nu_g^f) + \overline{A}_j}_{\equiv u_{fmj}} + \xi_{ifj}\,. \tag{G4}$$

G.1 Equilibrium

The model's equilibrium is characterized by three main equations:

$$N_j = \sum_f\sum_m N_{fmj} \text{ with } N_{fmj} = \frac{\exp\left(\lambda_f u_{fmj}\right)}{\sum_{j'}\exp\left(\lambda_f u_{fmj'}\right)} \quad \forall\, j \in J\,, \tag{G5a}$$

$$H_j^d = H_j^s \text{ with } H_j^d = \sum_f\sum_m N_{fmj}\cdot h^*_{fmj} \text{ and } H_j^s = B_j p_j^{\eta_j^{s,p}} \quad \forall\, j \in J\,, \tag{G5b}$$

$$g_j = t_j p_j N_j^{-\theta} H_j^d \quad \forall\, j \in J\,. \tag{G5c}$$

Totally log-differentiating equation (G5c) and using the notation $\dot{x} = dx/x$ yields:

$$\dot{g}_j = \dot{t}_j + (1+\eta_j^{s,p})\dot{p}_j - \theta\sum_f\sum_m s_{fmj}\dot{N}_{fmj}\,. \tag{G6}$$

Totally log-differentiating equation (G5b) yields:

$$\sum_f\sum_m \pi_{fmj}\dot{N}_{fmj} - \left(\rho_j + \eta_j^{s,p}\right)\dot{p}_j = \frac{t_j}{1+t_j}\rho_j\dot{t}_j\,,$$

where $\pi_{fmj} \equiv H^d_{fmj}/H^d_j$ is household type $\{f,m\}$'s share of aggregate housing demand, and $\rho_j \equiv \sum_f\sum_m \pi_{fmj}(1-(1-\alpha)\frac{\nu_h^f}{h^*_{fmj}})$ collects other parameters.

Finally, totally log-differentiating equation (G5a) for a given municipality j and household type $\{f,m\}$, yields:

$$\frac{1}{\alpha\lambda_f}\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right)\dot{N}_{fmj} + \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right)\theta\sum_f\sum_m s_{fmj}\dot{N}_{fmj} + \left[1-\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right)\left(1+\eta_j^{s,p}\right)\right]\dot{p}_j = \left[\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h^*_{fmj}}\right) - \frac{t_j}{1+t_j}\right]\dot{t}_j\,.$$

Stacking the $\mathcal{F}\times\mathcal{M}$ population equations and the equilibrium rental price solution into a system of equations yields

$$\mathbf{A_j}\dot{\mathbf{y}}_\mathbf{j} = \mathbf{B_j}\dot{\tau}_j\,, \tag{G7}$$

where

$$\mathbf{A_j} = \begin{bmatrix} \frac{1+\delta\left(\frac{g_j}{g_j-\nu_g^1}\right)\theta s_{11j}\lambda_1}{\alpha\lambda_1}\left(1-\frac{\nu_h^1}{h_{11j}^*}\right) & \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{11j}^*}\right)\theta s_{12j} & \cdots & \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{11j}^*}\right)\theta s_{\mathcal{FM}j} & 1-\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{11j}^*}\right)\left(1+\eta_j^{s,p}\right) \\ \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{12j}^*}\right)\theta s_{11j} & \frac{1+\delta\left(\frac{g_j}{g_j-\nu_g^1}\right)\theta s_{12j}\lambda_1}{\alpha\lambda_1}\left(1-\frac{\nu_h^1}{h_{12j}^*}\right) & \vdots & \vdots & \vdots \\ \vdots & \cdots & \ddots & \vdots & \vdots \\ \delta\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right)\theta s_{\mathcal{F}1j} & \cdots & \cdots & \frac{1+\delta\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)\theta s_{\mathcal{FM}j}\lambda_{\mathcal{F}}}{\alpha\lambda_{\mathcal{F}}}\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right) & 1-\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right)\left(1+\eta_j^{s,p}\right) \\ \pi_{11j} & \cdots & \cdots & \pi_{\mathcal{FM}j} & -\left(\rho_j+\eta_j^{s,p}\right) \end{bmatrix}$$

and

$$\mathbf{B_j} = \begin{bmatrix} \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^1}\right)\left(1-\frac{\nu_h^1}{h_{11j}^*}\right)-\frac{t_j}{1+t_j} \\ \vdots \\ \frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^{\mathcal{F}}}\right)\left(1-\frac{\nu_h^{\mathcal{F}}}{h_{\mathcal{FM}j}^*}\right)-\frac{t_j}{1+t_j} \\ \frac{t_j}{1+t_j}\rho_j \end{bmatrix}.$$

G.2 Incidence

Overall renter household welfare is given by

$$\mathcal{W}^R = \sum_f \sum_m s_{fm} \cdot \frac{1}{\lambda_f} \log\left(\sum_j \exp(\lambda_f u_{fmj})\right).$$

The effect of a change in the property tax rate of municipality j on the welfare of household type $\{f, m\}$, abstracting from general equilibrium effects on other jurisdictions, is given by

$$\frac{d\mathcal{W}_{fm}^R}{d\ln t_j} = \alpha N_{fmj}\left(1-\frac{\nu_h^f}{h_{fmj}}\right)^{-1}\left\{-\left[\frac{t_j}{(1+t_j)}-\frac{\delta}{\alpha}\left(\frac{g_j}{g_j-\nu_g^f}\right)\left(1-\frac{\nu_h^f}{h_{fmj}}\right)\left(\frac{dg_j}{dt_j}\frac{t_j}{g_j}\right)\right]-\left(\frac{dp_j^*}{dt_j}\frac{t_j}{p_j^*}\right)\right\}, \quad \text{(G8)}$$

where $\frac{dg_j}{dt_j}\frac{t_j}{g_j}$ and $\frac{dp_j^*}{dt_j}\frac{t_j}{p_j^*}$ are given by equation (G6) and by solving the system of equations (G7).

H Housing supply: details

In this section, we present a modified version of the setting proposed in (Jan K Brueckner, 2011, Ch.6). Atomistic absentee landlords own a stock of dwelling space with a net-of-tax rental revenue of $(1-\tau_j)p_j H(k, l_j)$, where p_j is the rental price per square meter, which is considered as given.[6] $H(k, l_j)$ represents a concave constant returns to scale housing produc-

[6]While landlords are absentee, to be consistent with our simplifying assumption, we assume that they pay a tax on rental income in the jurisdiction in which their dwelling is located, to be consistent with our empirical setting.

tion function, using non-land capital k and land l_j as inputs.[7] Non-land capital is rented at price r_k and land rent per unit is r_l.[8] The cost of housing is given by $C(k, l_j) = r_k k + r_l l_j$, which is financed entirely with mortgage debt. Non-land capital is assumed to be supplied perfectly elastically, making r_k an exogenously fixed parameter.

Landlords need to cover running costs when supplying the rental market. To simplify notation, let x_j denote the capital-land ratio k/l_j, which can be interpreted as building density or height. Substituting x_j, a landlord's profit maximization program is

$$\max_{x_j} \; l_j [(1-\tau_j) p_j h(x_j) - ac(x_j)] \,, \tag{H1}$$

where $h(x_j) \equiv H(x_j, 1)$ and $c(x_j) \equiv C(x_j, 1)$ denote the dwelling space and housing cost per unit of land, and γ represents the fraction costs effectively borne by landlords after consideration of tax deductions. The h function satisfies $h'(x_j) \equiv H_1(x_j, 1) > 0$ and $h''(x_j) \equiv H_{11}(x_j, 1) < 0$.

Given a fixed parcel of land, l_j, the landlord chooses x_j to maximize profit per unit of land, given by equation (H1), while land prices adjust until profits per unit of land are zero. Due to the fact that profits are zero, for any value of l_j, the scale of the landlord's building is indeterminate. The maximization of (H1) with respect to x_j and the zero profit condition are

$$(1-\tau_j) p_j h'(x_j^*) = ar_k, \tag{H2a}$$

$$(1-\tau_j) p_j h(x_j^*) - ar_k x_j^* = ar_l^*. \tag{H2b}$$

The landlord's profit-maximizing dwelling stock per unit of land is given by $h(x_j^*)$, with x_j^* being the optimal structural density determined by (H2a).

The total dwelling stock in municipality j, using a Cobb-Douglas production function, is equal to

$$H_s^j = l_j \cdot h(x_j^*) = l_j \left[\frac{B(1-\tau_j)}{a} \frac{p_j}{r_k} \right]^{\eta^{s,p}} \,, \quad \forall \, j \in J \,, \tag{H3}$$

where $\eta^{s,p} \equiv B/(1-B)$ represents the housing supply elasticity of rental prices and $B \in [0, 1)$ is the Cobb-Douglas share of capital expenditure in housing production.[9] Furthermore, the endogenous price of land is r_l^*, which is determined by replacing x_j^* into (H2b). Finally, movements along the supply curve are measured by the housing supply elasticity with respect to rental prices. The partial derivative of equation (H3) with respect to p_j yields

[7] As in Jan K Brueckner (1987), the building is implicitly being split up into housing units (apartments) that consumers can then rent from the landlord.

[8] Factor prices are assumed to be strictly positive.

[9] See Pierre-Philippe Combes, Gilles Duranton and Laurent Gobillon (2021) for a discussion on the choice of the production function.

$$\frac{\partial H_s^j}{\partial p_j}\frac{p_j}{H_s^j} = \eta^{s,p} \geq 0\,. \tag{H4}$$

Tax deductibility assumptions In the model, the landlord incurs running costs when supplying the rental market with dwelling space. Mortgage interest payments are equal to $i \cdot C(k, l_j)$, where i denotes the interest rate. Over time, the landlord's housing stock depreciates at rate $\check{d}$, representing a cost of $\check{d} \cdot C(k, l_j)$. In addition, property taxes need to be paid, which amount to $b_1 \cdot C(k, l_j)$, where b_1 is the property tax rate. Furthermore, transaction taxes b_2 are due if housing stock is sold and amount to $b_2 \cdot C(k, l_j)$, in the event of a sale. Finally, capital gains through appreciation of housing prices reduce costs by $g \cdot C(k, l_j)$.[10] If all costs are deductible and capital gains are taxed at the same rate as income, we can collect the various running costs and define the fraction of the housing stock's value allocated to running costs as

$$a = (1 - \tau_j)\check{a}\,,$$

with $\check{a} = (i + d + b_1 + b_2 - g)$. In this case, equation H3 becomes

$$H_s^j = l_j \left[\frac{B}{\check{a}}\frac{p_j}{r_k}\right]^{\eta^{s,p}}\,,$$

and housing supply is independent of changes in income tax rates.

[10]Capital gains g represent the expected rate of increase in housing value. Bear in mind that this source of revenue is only realized at the sale of the housing stock, but is still anticipated.

References

Brueckner, Jan K. 1987. "The structure of urban equilibria: A unified treatment of the Muth-Mills model." *Handbook of Regional and Urban Economics*, 2: 821–845.

Brueckner, Jan K. 2011. *Lectures on urban economics.* MIT Press.

Combes, Pierre-Philippe, Gilles Duranton, and Laurent Gobillon. 2021. "The production function for housing: Evidence from France." *Journal of Political Economy*, 129(10): 2766–2816.

Parchet, Raphaël. 2019. "Are local tax rates strategic complements or strategic substitutes?" *American Economic Journal: Economic Policy*, 11(2): 189–224.

Schmidheiny, Kurt, and Sebastian Siegloch. 2023. "On Event Studies and Distributed-Lags in Two-Way Fixed Effects Models: Identification, Equivalence, and Generalization." *Journal of Applied Econometrics*, , (forthcoming).

Swiss Federal Statistical Office. 2012. "Eidgenössisches Gebäude- und Wohnungsregister, Version 3.6 [Database]." *Neuchâtel, last accessed 2015-04-21.*

Swiss Federal Statistical Office. 2016. "Federal Population Census (1850-2000)." *Neuchâtel, last accessed 2017-05-17.*