Fiscal Externalities in Multilevel Tax Structures: Evidence from Concurrent Income Taxation

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Fiscal externalities in multilevel tax structures: Evidence from concurrent income taxation*

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Abstract

This paper exploits the multi-tiered structure of personal income taxation in Italy to investigate within-tier (horizontal) and between-tiers (vertical and diagonal) fiscal externalities. Estimation of an unrestricted income tax reaction function on municipalities located at internal regional borders using off-border Wald-type grouping variables as well as the staggered schedule of mayoral elections as instruments for endogenous spatial lags reveals strong positive spatial dependence in municipal tax rates. On the other hand, there is no evidence of a response of municipal tax rates to regional tax policies, suggesting that border discontinuity estimators that rely on consolidated spatial specifications (lower-plus-upper-tier tax rates) impose restrictions on the parameters of the reaction function that are unwarranted in these circumstances.

JEL classification: H24; H71; H73

Key words: fiscal externalities; income taxation; grouping instrumental variable; border discontinuity estimator.

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1 Introduction

In the absence of formal or substantive barriers to internal migration, decentralized taxation of personal income - a common feature of tax structures both in North America and in Europe - can in principle exert an influence on the location of taxpayers, particularly those at the upper end of the income distribution. In addition, it is frequent for high-income taxpayers in fiscally decentralized structures to adopt tax planning strategies such as transferring personal assets or their residency to lower taxed jurisdictions, irrespective of the effective location of their business or employment (Milligan and Smart, 2019). Given the potential threat that income tax base mobility poses on the ability of governments to collect revenues to provide public services and achieve the desired degree of income redistribution, the issue has been attracting increasing interest in the applied public economics literature in the most recent years (Basten et al., 2017; Schmidheiny and Slotwinski, 2018; Agrawal and Foremny, 2019; Eugster and Parchet, 2019; Lundberg, 2021). Indeed, a well-known consequence of the income tax base responsiveness to fiscal differentials is that decentralized tax setting decisions will end up being interdependent due to the fiscal externality that each authority inflicts on the other authorities when setting its own policy, possibly leading to an inefficient 'race to the bottom' in income tax rates - a phenomenon of substantive policy relevance (Kleven et al., 2020).

From an econometric point of view, the major issue that needs to be addressed when studying the tax-setting behavior of decentralized authorities is the simultaneous determination of the fiscal policies at the various locations of the spatial structure, making consistent estimation of a tax reaction function problematic (Gibbons and Overman, 2012). As a result, a recent and growing literature investigates the existence of strategic interaction in tax policy by exploiting the rare circumstances of decentralized decision-makers being hit by heterogeneous shocks (Lyytikainen, 2012; Di Porto and Revelli, 2013; Isen, 2014; Baskaran, 2014). These shocks can arise from changes in the tax and expenditure limitations or mandates that states impose on local governments or from fiscal reforms that generate geographically defined control and treatment groups by producing discontinuities at internal borders (Revelli and Bracco, 2020).

This paper aims at exploiting the multi-tiered structure of income taxation in Italy to investigate empirically the sign and size of fiscal externalities both between authorities at the same tier (municipal level) and between authorities at different tiers (lower-level municipalities and upper-level regions) by employing competing estimation approaches. In particular, we estimate tax reaction functions for municipalities located at internal regional borders, thus exploiting the substantial variability of regional policies across those borders that is observed in the Italian set-up. As concerns the key issue of endogeneity of horizontal spatial lags in the reaction function, we first address it by using Wald-type grouping variables (Blundell et al., 1998; Kleven et al., 2013) - that in this context take the form of cell averages of tax rates set by authorities that are not located at internal borders - as well as the staggered schedule of municipal elections (Ferraresi, 2020) as instruments. We then compare these results to those that are obtained when applying a recently developed border discontinuity estimator on a consolidated specification of the tax reaction function collapsing upper-tier and lower-tier tax rates in a single variable (Parchet, 2019). The border discontinuity estimator uses the tax policy of the regional authority across the border as an instrument for the potentially endogenous weighted average of consolidated neighbors' fiscal policies.

Based on a two-decades long panel dataset of municipal and regional income tax rates in Italian jurisdictions that are adjacent to internal regional borders, estimation of an income tax reaction function using Wald-type grouping instrumental variables and the staggered timing of municipal elections returns virtually no evidence of fiscal externalities from regional authorities to municipal ones, and significant evidence of positive spatial dependence in income tax rates between neighboring municipalities. These results suggest the the employment of a border discontinuity instrumental variable estimator on a consolidated specification requires imposing restrictions on the parameters of the fiscal reaction function - namely the equality of within-tier and cross-tier fiscal responses - that seem unwarranted in these circumstances. The results turn out to be robust to a number of further checks including the use of average rates in place of top marginal rates. Finally, both approaches return evidence of some sensitivity of the income tax base to local tax differentials.

The rest of the paper is structured as follows. Section **2** introduces the fundamental issues in the specification and estimation of an income tax reaction function in a multi-tiered structure of government where various forms of fiscal externalities might arise. Section **3** describes the Italian institutional context and the dataset, section **4** presents the main estimation results, and section **5** performs a number of further tests and robustness checks. Section **6** concludes.

2 Tax reaction functions

2.1 Specification

Consider a two-tier structure of government, where lower-tier authorities - municipalities, indexed by i - and upper-tier authorities - regions, indexed by c - concurrently set a proportional tax rate on a locally mobile income tax base according to a residence-based principle. Denote the respective tax rates as r_{ic} for municipality i located in region c, and r_c. We focus on region c's municipalities that are adjacent to a 'foreign' region, indexed by f, and we refer to them as 'border municipalities.' However, in each region there exists a set of 'internal municipalities' that are located off the border. If the tax base is locally mobile due to taxpayers choosing their place of residence based (also) on local tax differentials, closeness to the regional border implies that the income tax base in the border municipality i might in principle be affected by the tax policies of the nearby municipalities located either in the same or in the other region (a horizontal externality; Hayashi and Boadway, 2001), by the tax policy of the own region r_c (a vertical externality; Keen, 1998) and by the tax policy of the foreign region r_f (a diagonal externality; Agrawal, 2016). The presence of these fiscal externalities generates in turn a reaction function where the optimal tax rate of a revenue-maximising border municipality depends on the tax policies set by lower-tier and upper-tier authorities both in the own and in the foreign region.

In order to formalise the potential dependence of the tax policy of municipality i on its neighbors' tax policies, let Ω_{ic} and Ω_{if} denote the sets of municipalities in the own region c and in the adjacent foreign region f that belong to its 'cross-region neighborhood,' and adopt the conventional practice of weighing neighboring municipalities by standardised uniform weights. This implies that, for a neighborhood including N_i spatial units, and letting j and k index municipalities from the own and the foreign region respectively, each neighbor is attributed a weight w_{ij} or w_{ik} equal to:

$$w_{ij} = \begin{cases} \frac{1}{N_i} & \text{if} \quad j \in \Omega_{ic} \\ 0 & \quad\quad\; j \notin \Omega_{ic} \end{cases} \; ; \quad w_{ik} = \begin{cases} \frac{1}{N_i} & \text{if} \quad k \in \Omega_{if} \\ 0 & \quad\quad\; k \notin \Omega_{if} \end{cases} \tag{1}$$

$$\sum_{j \in \Omega_{ic}} w_{ij} + \sum_{k \in \Omega_{if}} w_{ik} = \frac{\sum \mathbf{1}(j \in \Omega_{ic})}{N_i} + \frac{\sum \mathbf{1}(k \in \Omega_{if})}{N_i} = \frac{N_{ic}}{N_i} + \frac{N_{if}}{N_i} = 1 \tag{2}$$

$\frac{N_{ic}}{N_i}$ and $\frac{N_{if}}{N_i}$ are the shares of internal (same region's) and external (foreign region's) municipalities in the neighborhood, and, as we discuss below, they play an important role in the empirical model.

In its general form, and with t indexing time, the empirical tax reaction function can consequently be expressed as:

$$r_{ic,t} = \alpha_1 \overline{r}_{-i,t} + \alpha_2 \overline{r}_{(i)c,t} + \alpha_3 \overline{r}_{(i)f,t} + \mu_{ic,t} \tag{3}$$

where the stochastic component $\mu_{ic,t} = \theta_i + \phi_{c,t} + \varepsilon_{ic,t}$ includes a municipality-specific time-invariant term (θ_i), a region-year effect ($\phi_{c,t}$) and an idiosyncratic time-varying error term that can be allowed to display a spatial pattern ($\varepsilon_{ic,t}$), and where the parameters α_1, α_2 and α_3 capture the response of municipality i's tax policy to changes in adjacent municipalities' tax policies, own region's tax policy and foreign region's tax policy respectively:

$$\begin{aligned} \overline{r}_{-i,t} &\equiv \sum_{j \in \Omega_{ic}} w_{ij} r_{jc,t} + \sum_{k \in \Omega_{if}} w_{ik} r_{kf,t} && (4) \\ \overline{r}_{(i)c,t} &\equiv \sum_{j \in \Omega_{ic}} w_{ij} r_{c,t} = \frac{N_{ic}}{N_i} r_{c,t} && (5) \\ \overline{r}_{(i)f,t} &\equiv \sum_{k \in \Omega_{if}} w_{ik} r_{f,t} = \frac{N_{if}}{N_i} r_{f,t} && (6) \end{aligned}$$

It is clear that, from the point of view of municipality i in region c, the upper-tier rates $r_{c,t}$ and $r_{f,t}$ play different roles. In fact, the total impact of a change in the own region's tax rate $r_{c,t}$ on the tax policy of municipality i can be decomposed into two distinct effects. The first is the direct vertical externality produced on $r_{ic,t}$ by a change in $r_{c,t}$ that influences the ability of locality i to attract tax base. Such direct effect is subsumed in the region-year component of term $\mu_{ic,t}$ in equation (3) - $\phi_{c,t}$ - and is therefore not identified in general (Parchet, 2019). The second is the change in municipality i's tax rate that is provoked by the indirect effect a shock in $r_{c,t}$ has on locality i through the impact it has on all other localities belonging to its same region relative to the unaffected counterparts in the foreign region (α_2). Indeed, this effect is an increasing function of the share of internal neighboring municipalities relative to foreign municipalities in the neighborhood. On the other hand, equation (3) shows that a change in the foreign region's rate $r_{f,t}$ only affects locality i by altering its fiscal performance relative to its foreign neighborhood, with the effect being magnified by the share of foreign municipalities in i's neighborhood $\frac{N_{if}}{N_i}$.

2.2 Estimation

The key issue that arises when estimating equation (3) concerns potential endogeneity of the three variables $\overline{r}_{-i,t}$, $\overline{r}_{(i)c,t}$, and $\overline{r}_{(i)f,t}$. In order to get a consistent estimate of parameter α_1 capturing the horizontal spatial lag response, we first make the following assumption:

Assumption 1. *(Exogeneity of upper-tier's policies).* $E(\mu_{ic,t}r_{c,t}) = E(\mu_{ic,t}r_{f,t}) = 0$.

Assumption 1 establishes the exogeneity of upper-tier's fiscal policies. This amounts to ruling out the possibility of omitted neighborhood characteristics affecting the policy of border municipality i as well as those of the two regions municipality i's neighbors belong to, and that of reverse causality, or the idea that the own and foreign regions are themselves influenced in turn by the fiscal policy of municipality i. As for the former, while the presence of region-year effects does control for any omitted common influence on tax-setting behavior of all localities belonging to the region, allowing for time-varying neighborhood-level effects is not feasible for lack of degrees of freedom. However, if, as in our case, the regions are far larger than the municipalities located at the borders - frequently in the order of the thousands of times - the chances that local shocks at the border have a substantial impact on upper-tier governments' policies too are admittedly dim. Relatedly, as far as the second potential source of endogeneity is concerned, given that border municipalities tend to be small relative to the regions, the hypothesis of no reverse causality from upper-tier back to lower-tier authorities seems reasonable and is a common tenet of the theoretical and empirical tax competition literature (Altshuler and Goodspeed, 2005; Keen and Konrad, 2013; Milligan and Smart, 2019).

2.2.1 Border discontinuity estimator

Next, in order to tackle the remaining issue of endogeneity of neighboring municipalities' policies on the right hand side, a number of restrictions can be imposed on (3). Consider in particular the tax reaction function in equation (7) below, that is expressed in terms of 'consolidated' tax rates (equation (4) in Parchet (2019)):[1]

$$R_{ic,t} = \alpha_1 \overline{R}_{-i,t} + \zeta_{ic,t} \tag{7}$$

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[1] The set of control variables $\mathbf{X}_{ic,t}$ is omitted from (7) for simplicity

The consolidated tax rate $R_{ic,t}$ in (7) is defined as the sum of municipal $(r_{ic,t})$ and regional $(r_{c,t})$ tax rates:

$$R_{ic,t} \equiv r_{ic,t} + r_{c,t} \tag{8}$$

Similarly, the neighborhood variable $\overline{R}_{-i,t}$ in (7) is a weighted average of the consolidated tax rates in the N_{ic} localities in Ω_{ic} and in the N_{if} localities in Ω_{if}:

$$\begin{aligned}
\overline{R}_{-i,t} &= \sum_{j\in\Omega_{ic}} w_{ij}\left(r_{jc,t}+r_{c,t}\right) + \sum_{k\in\Omega_{if}} w_{ik}\left(r_{kf,t}+r_{f,t}\right) \qquad (9)\\
&= \left(\sum_{j\in\Omega_{ic}} w_{ij} r_{jc,t} + \sum_{k\in\Omega_{if}} w_{ik} r_{kf,t}\right) + \frac{N_{ic}}{N_i} r_{c,t} + \frac{N_{if}}{N_i} r_{f,t}\\
&= \overline{r}_{-i,t} + \overline{r}_{(i)c,t} + \overline{r}_{(i)f,t}
\end{aligned}$$

Parchet (2019) addresses the issue of consistent estimation of α_1 in the presence of potential endogeneity of $\overline{R}_{-i,t}$ in the consolidated reaction function (7) arising from simultaneous determination of tax policies in the neighborhood, or $E\left(\zeta_{ic,t}|\overline{R}_{-i,t}\right) \neq 0$. Based on Assumption 1, Parchet (2019) proposes to estimate (7) by a border discontinuity instrumental variables approach that uses $\overline{r}_{(i)f,t} = \frac{N_{if}}{N_i} r_{f,t}$ as an instrument for $\overline{R}_{-i,t}$.

Indeed, consistency of this estimator hinges on correct specification of the reaction function (7), namely on the hypothesis that municipality i's tax rate reacts in the same way to changes in adjacent municipalities' $(\overline{r}_{-i,t})$, own region's $(\overline{r}_{(i)c,t})$ and foreign region's $(\overline{r}_{(i)f,t})$ tax policies.[2] In order to derive an expression for its bias in case $\alpha_1 \neq \alpha_2$ or $\alpha_1 \neq \alpha_3$, use (8) and (9) to rewrite (3) as:

$$R_{ic,t} = \alpha_1 \overline{R}_{-i,t} + \left[\left(\alpha_2-\alpha_1\right)\overline{r}_{(i)c,t} + \left(\alpha_3-\alpha_1\right)\overline{r}_{(i)f,t} + \mu_{ic,t}\right] \tag{10}$$

Assuming $E\left(\overline{r}_f^{'}\mu\right) = 0$, the expected value of an estimator of α_1 that uses $\overline{r}_{(i)f,t}$ as an instrumental variable for $\overline{R}_{-i,t}$ in (10) is:

$$\begin{aligned}
E\left(\widehat{\alpha}_1\right) &= \left(\overline{r}_f^{'}\overline{R}\right)^{-1}\overline{r}_f^{'}\left\{\alpha_1\overline{R} + \left[\left(\alpha_2-\alpha_1\right)\overline{r}_c + \left(\alpha_3-\alpha_1\right)\overline{r}_f + \mu\right]\right\} \qquad (11)\\
&= \alpha_1 + \frac{\alpha_2-\alpha_1}{\left(\overline{r}_f^{'}\overline{r}_c\right)^{-1}\overline{r}_f^{'}\overline{R}} + \frac{\alpha_3-\alpha_1}{\left(\overline{r}_f^{'}\overline{r}_f\right)^{-1}\overline{r}_f^{'}\overline{R}} \qquad (12)
\end{aligned}$$

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[2] Agrawal (2016) shows in a model of sales tax competition that the slopes of the reaction function for horizontal (town-town) and diagonal (town-county) tax competition are not equal. Similarly, the slopes will in general not be equal under yardstick competition (Revelli, 2005).

The first source of bias is a function of the difference in the response of a municipality's tax policy to the own region's tax policy relative to neighboring municipalities' policies ($(\alpha_2 - \alpha_1)$), weighted by the reciprocal of the impact the instrument $\overline{r}_f$ exerts on the endogenous consolidated neighborhood rate $\overline{R}$ through $\overline{r}_c$. The second potential source of bias is a function of the difference in the response to the foreign region's tax policy relative to the average municipal policy ($(\alpha_3 - \alpha_1)$), weighted by the reciprocal of the least squares estimate of the effect of the instrument $\overline{r}_f$ on $\overline{R}$ (the first stage of the IV procedure). In the end, whether the border-discontinuity estimator delivers unbiased estimates of α_1 turns out to depend on the plausibility of the restrictions that need to be imposed in order to move from the unrestricted specification (3) to the consolidated specification (7) of the reaction function.

2.2.2 A grouping instrumental variables approach

An alternative approach consists in sticking to specification (3) and estimating the distinct parameters of that more flexible reaction function. Under Assumption 1, the key remaining problem is endogeneity of the horizontal spatial lag $\overline{r}_{-i,t}$. This section outlines a Wald-type grouping estimator (Blundell et al., 1998) using the tax policies of 'internal' localities that are not exposed to border influences averaged over a number of dimensions as instrumental variables for border municipalities' tax policies, and discusses under what conditions it yields a consistent estimate of parameter α_1.

In particular, the estimator uses grouping instrumental variables, that is, cell averages of income tax rate policies, where cells are defined according to the following three dimensions: time (year of observation), location (municipalities belonging to the same region while not to the same neighborhood as the endogenous variable they instrument), and size (Kleven et al., 2013). As far as the latter dimension is concerned, and for the sake of parsimony, resident population is used in that it has proved to be an important determinant of the fiscal policies of local governments (Breunig and Rocaboy, 2008; Blom-Hansen et al., 2014).

In practice, in the presence of the typical multi-jurisdictional cross-region neighborhood that is found in our data, the grouping instrumental variable is computed as follows. First, for each of the $N_i = N_{ic} + N_{if}$ localities constituting the cross-region neighborhood of locality i - equation (4) - compute the respective cell average tax rate, that is, the mean contemporaneous tax rate of all internal (non-border) authorities of a similar population size (as defined in equation (14) below) and belonging to the same region as the locality in the neigborhood (either the own or the foreign region). Next, construct the grouping instrumental variable for the endogenous neighborhood tax rate $\overline{r}_{-i,t}$ of a locality i as the mean of those cell averages, weighted by weights w_{ij} for internal municipalities and w_{ik} for 'foreign' ones, as in equation (13):

$$\begin{aligned} \overline{g}_{-i,t} &= \overline{g}_{i(c),t} + \overline{g}_{i(f),t} \\ &= \sum_{j \in \Omega_{ic}} w_{ij} g\left[t, c, D\left(p_{jc,t}\right)\right] + \sum_{k \in \Omega_{if}} w_{ik} g\left[t, f, D\left(p_{kf,t}\right)\right] \end{aligned} \tag{13}$$

with $g\left[t, c, D\left(p_{jc,t}\right)\right]$ and $g\left[t, f, D\left(p_{kf,t}\right)\right]$ denoting the cell means of top municipal personal income tax rates by year (t), region (c, f), and demographic group ($D\left(p_{jc,t}\right)$, $D\left(p_{kf,t}\right)$):

$$D\left(p_{\cdot,t}\right) = \begin{cases} 1 & & p_{\cdot,t} \leq 1,000 \\ 2 & & 1,000 < p_{\cdot,t} \leq 3,000 \\ 3 & & 3,000 < p_{\cdot,t} \leq 5,000 \\ 4 & \text{if} & 5,000 < p_{\cdot,t} \leq 10,000 \\ 5 & & 10,000 < p_{\cdot,t} \leq 15,000 \\ 6 & & 15,000 < p_{\cdot,t} \leq 30,000 \\ 7 & & 30,000 < p_{\cdot,t} \leq 50,000 \\ 8 & & p_{\cdot,t} > 50,000 \end{cases} \tag{14}$$

with this demographic group structure closely resembling the official administrative classification that is employed for the computation and distribution of state equalization grants to municipalities.

The strategy of identification of horizontal fiscal externalities (parameter α_1) by instrumenting the spatially averaged tax policy of cross-border neighborhoods' municipalities with time-region-size cell means of off-border municipalities' tax policies relies on the following two assumptions:

Assumption 2. *(Exogenous neighborhood demographic structure). Let* $\mathbf{D}'_{-i,t} = \left[\mathbf{D}'_{i(c),t}, \mathbf{D}'_{i(f),t}\right]$ *denote the vector of demographic group indicators for the* $N_i = N_{ic} + N_{if}$ *jurisdictions belonging to the neighborhood of locality* i, *and* $\mathbf{d}'$ *a vector of its realizations. Then:* $P\left(\mathbf{D}'_{-i,t} = \mathbf{d}' | r_{ic,t}\right) = P\left(\mathbf{D}'_{-i,t} = \mathbf{d}'\right)$.

Assumption 3. *(No higher-order spatial autocorrelation).* $E\left(\mu_{ic,t}\overline{g}_{-i,t}\right) = 0$.

Assumption 2 states that the demographic structure of locality i's neighborhood can be taken as a fixed feature in the sense that it is independent of the fiscal policy of authority i. Internal migration flows generated by local tax differentials are assumed not to be large enough as to provoke crossings of population class boundaries within a neighborhood. This implies in turn that each neighborhood's demographic structure can be employed to build the population cell averages that make up the instrumental variable that is subsequently used in the estimation procedure.

Finally, Assumption 3 rules out the possibility that the cell averages of 'internal' localities' fiscal policies in the own and the foreign region $\overline{g}_{-i,t}$ be incorrectly excluded from equation (3). This assumption excludes the possibility of a higher-order fiscal competition process, where all municipalities compete with each other for perfectly mobile taxpayers across the entire spatial structure. After conditioning on first order neighbors' tax policies $\overline{r}_{-i,t}$ as defined in (4), the instrument based on out-of-neighborhood jursidictions' tax policies is assumed to be orthogonal to the error term. This assumption is compatible with a sorting model with relocation costs, labor market rigidities or constraints in the housing market that make competition for imperfectly mobile tax bases a local phenomenon.

As concerns the relevance of the instrument, it is required that the trajectories of the cell-averaged local income tax rates display sufficient variation over time, between the demographic classes, and between the regions neighboring municipalities belong to - an issue we deal with in section **4** below.

2.2.3 Staggered elections and local budget cycles

In addition, we exploit an institutional feature of the Italian system of local government - the staggered schedule of mayoral elections[3] - that has proved to have a significant impact on the trajectory of municipal fiscal variables by creating a 'political budget cycle' (Alesina and Paradisi, 2017; Repetto, 2018; Revelli and Zotti, 2019). As far as local taxes are concerned, the existing evidence shows that tax rates on income and property tend to fall as mayoral elections approach and to rise again after the election is safely over. The fact that mayoral elections do not occur in the same years for all municipalities implies that nearby localities find themselves for random reasons at different points of their elec-

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[3] Most of the heterogeneity in the timing of elections arises from the unequal length of terms of office in the over sixty years from the restoration of democratic municipal elections after the end of WWII in Italy due to resignation, illness, impediment, death of the mayor, lack of majority of seats in the lcoal Council, or mandated termination by the Minsitry of the Interior (Repetto, 2018; Ferraresi, 2020).

toral cycles, making it possible to use neighboring jurisdictions' distance from the next election as an instrument for their fiscal policies in a local tax reaction function (Ferraresi, 2020).

Given the five-years electoral term of Italian local governments, we model the effect of the timing of municipal elections in a flexible nonlinear way through a vector of four dummy variables $e(t-l)_{ic,t}$ capturing the distance from the election and equalling 1 if there was an election in locality i in region c in the $l = 1, ..., 4$ years preceding year t:

$$\mathbf{e}'_{ic,t} = [e(t-1)_{ic,t}, ..., e(t-4)_{ic,t}]' \tag{15}$$

giving rise to the following set of instruments for the spatial lag $\bar{t}_{-i,t}$:

$$\begin{aligned} \overline{\mathbf{e}}_{-i,t} &= \overline{\mathbf{e}}_{i(c),t} + \overline{\mathbf{e}}_{i(f),t} \\ &= \sum_{j \in \Omega_{ic}} w_{ij} \mathbf{e}_{jc,t} + \sum_{k \in \Omega_{if}} w_{ik} \mathbf{e}_{kf,t} \end{aligned} \tag{16}$$

The validity of this set of instruments relies on the hypothesis that the fiscal policies of border municipalities are influenced by the timing of the elections in the jurisdictions belonging to their neighborhoods only through the incentives that the distance-to-the-elections variable creates on neighboring jurisdictions' tax policies, and have no direct impact on own policy-making strategies - an hypothesis that seems plausible under any reasonable local government accountability mechanism.

3 Local income taxation in Italy

We perform the empirical analysis on a panel dataset of around 900 Italian municipalities that are located at the internal regional borders of the 20 Italian regions, in the sense that each of those municipalities is adjacent to at least one municipality from a different region.[4] For both regions and municipalities, we have complete information on the key parameters of their income tax schedules, their tax bases and their demographic structure through the years 2003 to 2015. Most of the municipalities in the sample are small. About $\frac{3}{4}$ of them have less than 5,000 inhabitants, with *Genova* in the *Liguria* region being the only big city (around 600,000 inhabitants) bordering a different region (*Piemonte*).

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[4] Italy has over 8,000 municipalities in total. All municipalities that are not adjacent to a regional border are considered 'internal.'

Regional and municipal authorities independently set their income tax rates on the same personal income tax base as the national government. Tax rates can either be proportional or, after the 2011 reform, progressive. In the former case, the local government sets the flat rate that applies to taxpayers' gross income and works as a uniform surcharge on the progressive nationwide schedule. Starting from 2012, if regional and municipal authorities opt for progressive taxation they can set the marginal tax rates applying to different income brackets, but those brackets must be identical as the five ones set by the national government for its own share of the tax.[5] In addition, municipal and regional governments can introduce an income exemption threshold creating a no-tax-area for low income taxpayers.

Due to the operation of differential caps that the central government has been imposing on regional and local authorities during the past two decades and to the larger share of public spending responsibilities that is assigned to the regions (particularly as far as health services are concerned), income tax rates set by regional governments exceed by far the rates set by municipal governments. Before the introduction of progressivity in 2011, the average regional income tax rate was 1.3%, about three times larger than the average municipal income tax rate (0.4%), and the gap widened thereafter. In 2015, the average top regional tax rate grew to 2.1% relative to a 0.6% average top municipal tax rate. In fact, during the period we analyze the variation in upper-tier rates has been considerable both over time and between regions, with a steep increase in the degree of progressivity. The average regional tax rate on a taxable income of euro 20,000 raised from below 1% in 2003 to just over 1.5% in 2015, while that on a taxable income of euro 80,000 almost doubled, from slightly above 1% in 2003 to around 2% in 2015. The differences in top marginal rates between regions have been remarkable too, implying that while within-region differences in income tax burdens end up being modest, taxpayers can face non-negligible differences in marginal and average income tax rates if they reside in different regions. For instance, the introduction of a steeply progressive schedule by the *Marche* region, culminating in a top tax rate of 4%, generated an over three percentage point marginal tax rate difference for high-income taxpayers (income>euro 75,000) living across the border in the adjacent regions of *Lazio*, *Abruzzo* or *Emilia Romagna* that were facing a proportional rate of only 0.9%

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[5] These brackets are: up to €15,000 yearly gross income; €15,000 to €28,000; €28,000 to €55,000; €55,000 to €75,000; above €75,000.

there. Similarly, high-income taxpayers living in *Piemonte* in 2015 would have a two percentage point tax rate gain by crossing the border and having their incomes taxed in the adjacent region of *Lombardia*.

As the main dependent variable in our empirical analysis we first employ the top marginal income tax rate set by municipal governments, that is the tax rate applied on total taxable income exceeding euro 75,000 (or on the entire tax base in case the municipal authority applies a proportional rate), and use the corresponding regional top tax rate as far as the vertical and diagonal interactions with the regional authorities are concerned. In the robustness checks section, we extend the analysis to average tax rates for various levels of taxable income (euro 20,000 to euro 80,000) as the dependent variable. Descriptive statistics for all the variables used in the analysis are reported in table 1.

4 Estimation results

Table 2 reports the estimate of the α_1 coefficient from the consolidated spatial reaction function (7) when applying the just identified IV estimator that uses neighboring regions' top marginal tax rates $\overline{r}_{(i)f,t}$ defined in (6) as an instrument for the endogenous consolidated neighbors' tax rate $\overline{R}_{-i,t}$. As a benchmark, the first column reports OLS estimates. The dataset refers to observations from the years 2003 to 2015 on the Italian municipalities that are located at internal regional borders. Reported standard errors are clustered at the level of the 75 provinces municipalities belong to (the intermediate level of government between the municipalities and the regions) in order to control for local residual spatial auto-correlation, and the stochastic term includes municipality-specific fixed effects and region-year effects. The equation also includes the grouping variable $\overline{g}_{i,t}$ (the municipal top marginal income tax rates averaged by region, year, and population bracket the municipality acting as the dependent variable belongs to) as a control. However, as discussed below, the results are unchanged when dropping it.

The OLS estimate of the α_1 coefficient in column (1) of table 2 points to positive and statistically significant spatial dependence in consolidated municipal-plus-regional top income tax rates, though the estimated coefficient is extremely small (0.05). As in Parchet (2019), the coefficient turns negative when estimated by the border-discontinuity instrumental variable approach in column (2). The first stage results in column (3) show that the instrument is highly correlated with the endogenous variable (in fact it is a component of it, as shown by equation (9)). The estimated second-stage spatial interaction coefficient is however not estimated to be significantly different from zero, and so is the reduced-form estimate in column (4). Finally, probably due to the fact that the equation includes region-year effects, the grouping variable $\overline{g}_{i,t}$ used as a control is roughly orthogonal to $\overline{R}_{-i,t}$ (column (3)). As a result, (unreported) estimation results turn out to be virtually identical when omitting $\overline{g}_{i,t}$ from equation (7).

We next estimate the unrestricted specification (3) and report the results in table 3. Column (1) presents again benchmark OLS estimates. As for the key spatial auto-correlation coefficient, the OLS estimate of α_1 takes on a considerably larger value of around 0.32, while the vertical interaction coefficient on the own region's tax rate (α_2) and the diagonal interaction coefficient on the foreign region's tax rate (α_3) are virtually zero. This explains the bias towards zero of the OLS estimate of the α_1 coefficient that the consolidated spatial reaction function (7) returns in these circumstances.

Indeed, though, the endogenous determination of municipal tax policies within the cross-region neighborhoods will tend to bias the estimate of α_1 upwards in the unrestricted specification (3) if local tax rates are strategic complements. Column (2) of table 3 reports the results of IV estimation of equation (3) using the grouping variable $\overline{g}_{-i,t}$ discussed above as an instrument for $\overline{r}_{-i,t}$. Given that the reaction function controls for region-specific time-varying effects ($\phi_{c,t}$), it is the differential trajectory of municipal tax rates across demographic groups, coupled with the diverse composition of neighborhoods in terms of population size of its member localities, that provides the necessary source of variation for the grouping instrument to identify the α_1 coefficient on the spatial lag.

Figure 1 shows the path of the top municipal marginal income tax rate averaged by the eight population brackets in (14) across all regions. Figure 1 highlights two important aspects of the evolution of those tax rates during the period of observation. First, municipal tax rates were hit by two visible and permanent shocks, in 2007 and in 2012. The 2007 one corresponds to the nation-wide relaxation of the upper limit on the tax rate that municipalities could set, from 0.5% to 0.8% of total taxable income, that was followed by a widespread increase in rates. The 2012 shock corresponds to the introduction of the possibility for municipal governments to set progressive income tax rate schedules. That reform allowed local authorities to raise top rates on the highest incomes, while not imposing excessive burdens on average and low-income taxpayers, an opportunity that municipal authorities seem to have used extensively. Second, figure 1 shows that the trajectories of the top income tax rates in the municipalities belonging to the different demographic groups were indeed highly heterogeneous, with tax rates in the larger municipalities growing at a considerably faster pace than those in the smaller ones, leading to an impressive increase in the variance between demographic group averages during that period that lends support to the hypothesis of relevance of the grouping instrument.

In fact, the first stage estimation results in column (3) of table 3 show that the grouping instrumental variable performs well as a predictor of the spatially lagged endogenous variable, with a large and statistically significant coefficient of around 0.8 and an F test of over 80. In the second stage (column (2)), the grouping instrumental variable approach returns an estimate of α_1 that is positive and about 0.28, pointing to a mild upward bias from OLS estimation of the flexible reaction function (3).

Finally, column (4) reports the estimates of the same equation when adding neighbors' electoral cycle indicators as instruments, along with own electoral cycle indicators as controls. The first stage estimates in column (5) reveal that those distance-from-election dummies predict the trajectory of tax rates over the political cycle in a plausible way, with tax rates showing a tendency to rise right after an election. Moreover, they do have some explanatory power, though not an overwhelming one (F test on the instruments of around 18), as also confirmed by their respective estimated coefficients in the main equation (column (4)). This overidentified IV approach returns a similar estimate of the spatial autoregressive coefficient α_1 of about 0.27, and the Hansen-Sargan overidentification test cannot reject the hypothesis of instruments' validity.

5 Robustness

5.1 Average tax rates

This section verifies the sensitivity of the above evidence to a number of alternative tests and specifications. First, tables 4 and 5 report the estimation results of the tax reaction functions when using average tax rates in place of top marginal tax rates. In particular, we compute the average income tax rate for taxpayers with total taxable income of euro 20,000, 30,000, 40,000, 50,000, 60,000, 70,000, and 80,000. Table 4 reports the estimation results when using average tax rates as the dependent variable in the consolidated specification (7), while table 5 reports the results for the unrestricted specification (3). As one should expect given the convergence of average to top statutory income tax rates as income rises, the evidence emerging when employing average tax rates is similar to that from top marginal rates as far as the highest incomes are concerned. In the consolidated specification of table 4, OLS estimates for all levels of income turn out to be positive and statistically significant. However, when foreign regions' rates are used as instruments all estimates turn negative an insignificant. On the other hand, when estimated with the grouping variables and the timing of elections indicators discussed above as instruments for the endogenous spatial lag in the unrestricted specification, the α_1 coefficient in table 5 turns out to be around 0.2, relative to an OLS estimate of over 0.3. The IV estimates turn out to be only marginally or not statistically significant for lower levels of income. This result is compatible with the hypothesis that local authorities compete over tax rates on wealthy taxpayers, whose tax base is the most elastic to local tax differentials thanks to high income individuals' access to income shifting opportunities, rather than over tax rates on less mobile tax bases.

5.2 Pairwise approach

Tables 6 and 7 report the estimation results when employing a pairwise approach similar to the one performed in Parchet (2019), section III.B. With this approach, the reaction functions are estimated on all pairs p of neighboring municipalities that are located across the border of different regions:

$$R_{i,t} = \alpha_1 R_{-i,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{17}$$

$$r_{i,t} = \alpha_1 r_{-i,t} + \alpha_3 r_{f,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{18}$$

where γ_p is a pair-specific fixed effect and $\delta_{c,t}$ is the usual region-year dummy variable. In equation (17), $R_{-i,t}$ denotes the consolidated tax rate of municipality i's neighboring municipality that is located across the border in region f, while in the unrestricted specification (18) the regional and municipal tax rates of the foreign neighboring locality are allowed to have different coefficients. In these specifications, each locality appears as many times as is its number of neighbors across the border, multiplied by the number of years its tax policy is observed. Indeed, by focusing on the pairs of neighboring municipalities on opposite sides of a regional border, this pairwise specification explicitly omits the

N_{ic} 'internal' neighbors' tax rates as well as $N_{if} - 1$ 'external' neighbors' - i.e., all foreign neighbors except the paired one. As a result, if the tax rates of the authorities belonging to a cross-region neighborhood are positively correlated irrespective of whether they belong to the same or to different regions, omitting $N_i - 1$ of a locality's neighbors from the reaction function will likely produce a downward bias on the OLS estimate of the horizontal interaction parameter α_1.

Equation (17) is estimated by using $r_{f,t}$ as an instrument for $R_{-i,t} = r_{-i,t} + r_{f,t}$, while $g_{-i,t}$ in (19) and $\mathbf{e}_{-i,t}$ in (20) are used as instruments for $r_{-i,t}$ in equation (18):

$$g_{-i,t} = g\left[t, f, D\left(p_{-i,t}\right)\right] \tag{19}$$

$$\mathbf{e}_{-i,t} = \left[e(t-1)_{-i,t}, ..., e(t-4)_{-i,t}\right]' \tag{20}$$

where $g_{-i,t}$ is the grouping instrumental variable for the paired foreign neighbor and $\mathbf{e}_{-i,t}$ is the vector of its distance from election dummies.

The results of estimation of this specification go roughly in the same direction as those obtained when using the tax rates of all internal and external neighbors and collapsing them in a single variable. The interaction coefficient α_1 is in fact negative and insignificant in the consolidated specification using $r_{f,t}$ as an instrument for $R_{-i,t}$ (equation (17), table 6). On the other hand, it is positive and significant in the unconstrained one using $g_{-i,t}$ and $\mathbf{e}_{-i,t}$ as instruments for $r_{-i,t}$ (equation (18), table 7), with OLS delivering an estimate that appears to be biased towards zero.

5.3 Tax base response

As we have argued above, interdependence in municipal tax rates is likely to originate from the sensitivity of the income tax base to local tax differentials in the presence of taxpayers' ability to shift income to lower taxed municipalities. To verify if this is indeed the case, we report in tables 8 and 9 the estimation results of a tax base determination equation similar to equation (13) in Parchet (2019), that lets the spatial difference in the logarithm of the income tax base between a jurisdiction's tax base and the average tax base of its adjacent municipalities ($\nabla \ln(B_{i,t})$) to be a function of the corresponding spatial difference in consolidated - equation (21) - or unconsolidated - equation (22) - income tax rates:

$$\nabla \ln(B_{i,t}) = \rho \nabla R_{i,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{21}$$

$$\nabla \ln(B_{i,t}) = \lambda \nabla r_{i,t} + \phi \nabla r_{c,t} + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{22}$$

where ∇ denotes spatial differencing. Unlike Parchet (2019), though, we do not follow here the pairwise approach that, as shown above, is likely to lead to biased parameter estimates. Instead, we take the difference between a municipality's tax base and the average tax base across all of its internal and external neighborhood's municipalities as the dependent variable.

In specifications (21) and (22), parameters ρ, λ, and ϕ represent the semi-elasticities of the municipal tax base relative to local income tax rates (Milligan and Smart, 2019). For comparison purposes, the implied elasticities computed at the relevant sample mean tax rate values are reported at the bottom of tables 8 and 9.

In tables 10 and 11, we estimate two further specifications of the consolidated and unrestricted tax base equations that use instead the difference in the logarithms of top marginal tax rates as the key explanatory variable, thus directly returning in this case tax base elasticities with respect to consolidated tax rates (ϵ_ρ) or to municipal and regional tax rates (ϵ_λ, ϵ_ϕ):

$$\nabla \ln(B_{i,t}) = \epsilon_\rho \nabla \ln(R_{i,t}) + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{23}$$

$$\nabla \ln(B_{i,t}) = \epsilon_\lambda \nabla \ln(r_{i,t}) + \epsilon_\phi \nabla \ln(r_{c,t}) + \gamma_p + \delta_{c,t} + \varepsilon_{ic,t} \tag{24}$$

In all of the above specifications, $B_{i,t}$ is defined as the total income tax base from residents' personal income tax files, and the tax rates are top marginal rates.[6] In tables 8 and 10, the difference between the own and the foreign region's tax rate (or their logs) is used as an instrument for the consolidated difference $\nabla R_{i,t}$ ($\nabla \ln(R_{i,t})$). In tables 9 and 11, the difference between the own and the average neighborhood grouping instrumental variable (19) (or their logs) is used as an instrument for $\nabla r_{i,t}$ ($\nabla \ln(r_{i,t})$). $\nabla r_{c,t}$ and $\nabla \ln(r_{c,t})$ are again assumed to be exogenous throughout. In each of those tables, we report the results from contemporaneous specifications as well as from specifications that use one-year lags of tax rates.

Interestingly, the results of estimation when using either the consolidated or the unconsolidated specifications are similar, pointing to a negative impact of tax rate differentials on tax bases, with lagged specifications returning larger and more significant estimates of the tax base semi-elasticity and elasticity as far as equations (22) and (24) are concerned. The fact that the estimated elasticities are rather small is compatible with the hypothesis that interdependence

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[6] Additional sets of estimates using average tax rates are not reported to save space and are available on request.

in municipal fiscal policy is driven by mobility of only the fraction of the tax base that shows some responsiveness to local tax differentials.

6 Conclusions

This paper has exploited the multi-level structure of personal income taxation in Italy, and particularly the discontinuity of upper-tier top marginal tax rates at regional borders, to study the tax setting decisions of lower-tier authorities and ascertain the importance of within-tier and cross-tier fiscal interactions that arise from the hypothesis of imperfect income tax base mobility. We have discussed grouping instrumental variable estimators of first order spatial autocorrelation parameters in unrestricted specifications of municipal tax reaction functions and compared them to border discontinuity estimators of spatial reaction functions that use cross-border upper-tier tax policies as instruments for average consolidated tax rates in neighboring localities.

The results of estimation of an unrestricted tax reaction function using Wald-type grouping variables along with the staggered timing of municipal elections as instruments for endogenous spatial lags provide evidence of positive spatial dependence in municipal tax rates, but no evidence of vertical and diagonal fiscal interactions. This suggests that estimation of a consolidated fiscal reaction function that imposes the equality of within-tier and cross-tier external effects can lead to biased estimates of the spatial interaction parameters in these circumstances.

Finally, we have performed a number of further tests of the robustness of the evidence, including the use of average rather than top marginal tax rates and the estimation with a pairwise approach based on observations on all pairs of municipalities that are located across the border of different regions, consistently finding support for the hypothesis of significant positive horizontal interactions among municipalities as well as some sensitivity of the income tax base to local tax differentials.

Declarations of interest

None

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Tables

Table 1 Descriptive statistics

	obs.	mean	std.dev.	min	max
top municipal income tax rate	10,131	0.47	0.21	0	0.80
top regional income tax rate	10,131	1.97	0.57	0.90	4.00
average municipal income tax rate (€20,000)	10,131	0.45	0.20	0	0.80
average municipal income tax rate (€30,000)	10,131	0.46	0.20	0	0.80
average municipal income tax rate (€40,000)	10,131	0.46	0.20	0	0.80
average municipal income tax rate (€50,000)	10,131	0.46	0.20	0	0.80
average municipal income tax rate (€60,000)	10,131	0.46	0.20	0	0.80
average municipal income tax rate (€70,000)	10,131	0.47	0.20	0	0.80
average municipal income tax rate (€80,000)	10,131	0.47	0.20	0	0.80
average regional income tax rate (€20,000)	10,131	1.25	0.30	0.90	2.08
average regional income tax rate (€30,000)	10,131	1.32	0.31	0.90	2.14
average regional income tax rate (€40,000)	10,131	1.36	0.33	0.90	2.73
average regional income tax rate (€50,000)	10,131	1.38	0.36	0.90	2.85
average regional income tax rate (€60,000)	10,131	1.39	0.36	0.90	2.93
average regional income tax rate (€70,000)	10,131	1.39	0.37	0.90	2.99
average regional income tax rate (€80,000)	10,131	1.40	0.38	0.90	3.03
population	10,131	5,464	21,446	38	620,316
share of external neighbors	10,131	0.33	0.16	0.06	0.87

Table 2 Border discontinuity estimator: equation (7)

	(1)	(2)	(3)	(4)
	OLS	IV	first stage	reduced form
$\overline{R}_{-i,t}$	0.050**	-0.029		
	(0.015)	(0.023)		
$\overline{r}_{(i)f,t}$			0.582***	-0.017
			(0.069)	(0.013)
$\overline{g}_{i,t}$	0.559***	0.564***	0.162*	0.560***
	(0.087)	(0.088)	(0.087)	(0.088)
F			47.90***	
(p)			(0.000)	
obs.		10,131		
groups		866		

Notes: Standard errors clustered by province (75 clusters) in parentheses. Includes municipality and region-year effects. F: F-test on excluded instrument; ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 3 Estimation of spatial reaction function (3)

	(1)	(2)	(3)	(4)	(5)
	OLS	IV	first stage	IV	first stage
$\overline{r}_{-i,t}$	0.321^{***}	0.281^{**}		0.279^{**}	
	(0.045)	(0.119)		(0.117)	
$\overline{r}_{(i)c,t}$	0.003	0.003	0.011	0.003	0.011
	(0.019)	(0.020)	(0.013)	(0.020)	(0.013)
$\overline{r}_{(i)f,t}$	-0.011	-0.011	-0.001	-0.011	-0.001
	(0.010)	(0.011)	(0.008)	(0.011)	(0.008)
$\overline{g}_{i,t}$	0.504^{***}	0.511^{***}	0.043	0.510^{***}	0.043
	(0.086)	(0.083)	(0.039)	(0.083)	(0.039)
$\overline{g}_{-i,t}$			0.796^{***}		0.795^{***}
			(0.084)		(0.084)
$e(t-4)_{ic,t}$				0.004	0.001
				(0.003)	(0.001)
$e(t-3)_{ic,t}$				0.009^{**}	-0.003
				(0.003)	(0.001)
$e(t-2)_{ic,t}$				0.009^{***}	-0.001
				(0.003)	(0.001)
$e(t-1)_{ic,t}$				0.008^{**}	-0.001
				(0.003)	(0.002)
$e(t-4)_{-ic,t}$					0.002
					(0.005)
$e(t-3)_{-ic,t}$					0.006
					(0.005)
$e(t-2)_{-ic,t}$					0.007
					(0.05)
$e(t-1)_{-ic,t}$					0.009^{*}
					(0.005)
instruments			$\overline{g}_{-i,t}$		$\overline{g}_{-i,t}, \overline{\mathbf{e}}_{-i,t}$
F			88.16^{***}		18.32^{***}
(p)			(0.000)		(0.000)
H					0.55
(p)					(0.96)
obs.			10,131		
groups			866		

Notes: Standard errors clustered by province (75 clusters) in parentheses. Includes municipality and region-year effects. F: F-test on excluded instruments; H: Hansen test of overidentifying restrictions ($\chi^2_{(4)}$); ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 4 Spatial reaction function (7): average tax rates

	(1)	(2)
	OLS	IV
$R_{(€80,000)}$	0.087^{***}	-0.177
	(0.021)	(0.143)
$R_{(€70,000)}$	0.102^{***}	-0.214
	(0.023)	(0.179)
$R_{(€60,000)}$	0.110^{***}	-0.262
	(0.024)	(0.218)
$R_{(€50,000)}$	0.117^{***}	-0.311
	(0.025)	(0.258)
$R_{(€40,000)}$	0.137^{***}	-0.494
	(0.027)	(0.443)
$R_{(€30,000)}$	0.165^{***}	-0.814
	(0.028)	(0.800)
$R_{(€20,000)}$	0.197^{***}	-2.467
	(0.033)	(0.302)
obs.	10,131	
groups	866	

Notes: Estimates of the α_1 coefficient from equation (7) where the dependent variable is the average tax rate for taxpayers with taxable incomes of €20,000 to €80,000. Standard errors clustered by province (75 clusters) in parentheses. The equation includes municipality and region-year effects. IV: instrument is foreign region's tax rate; ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 5 Spatial reaction function (3): average tax rates

	(1)	(2)	(3)
	OLS	IV(I)	IV(II)
$r_{(€80,000)}$	0.331^{***}	0.240^{*}	0.242^{*}
	(0.045)	(0.140)	(0.148)
$r_{(€70,000)}$	0.333^{***}	0.236^{*}	0.239^{*}
	(0.045)	(0.143)	(0.141)
$r_{(€60,000)}$	0.334^{***}	0.232	0.235
	(0.046)	(0.147)	(0.144)
$r_{(€50,000)}$	0.334^{***}	0.237	0.241^{*}
	(0.047)	(0.148)	(0.146)
$r_{(€40,000)}$	0.333^{***}	0.218	0.222
	(0.047)	(0.152)	(0.150)
$r_{(€30,000)}$	0.336^{***}	0.197	0.204
	(0.045)	(0.161)	(0.159)
$r_{(€20,000)}$	0.336^{***}	0.219	0.227
	(0.045)	(0.169)	(0.165)
obs.		10,131	
groups		866	

Notes: Estimates of the α_1 coefficient from equation (3) where the dependent variable is the average tax rate for taxpayers with taxable incomes of €20,000 to €80,000. Standard errors clustered by province (75 clusters) in parentheses. The equation includes municipality and region-year effects. IV(I): instrument is grouping variable in (13); IV(II): instruments are grouping variable in (13) and distance to election dummies in (16); ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 6 Spatial reaction function (7): pairwise approach

	(1)	(2)	(3)
	OLS	IV	first stage
$R_{-i,t}$	-0.001	-0.008*	
	(0.004)	(0.005)	
$\overline{g}_{i,t}$	0.536***	0.535***	0.190***
	(0.104)	(0.104)	(0.066)
$r_{f,t}$			0.994***
			(0.007)
F			25490.07***
(p)			(0.000)
obs.		16,148	
groups		1,518	

Notes: Standard errors clustered by province (75 clusters) in parentheses. Includes pair and region-year effects. F: F-test on excluded instruments; ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 7 Spatial reaction function (3): pairwise approach

	(1)	(2)	(3)	(4)	(5)
	OLS	IV(I)	first stage	IV(II)	first stage
$r_{-i,t}$	0.053^{***}	0.182^{***}		0.176^{**}	
	(0.016)	(0.058)		(0.067)	
$r_{f,t}$	-0.008	-0.007	0.002	-0.007	0.001
	(0.005)	(0.005)	(0.004)	(0.005)	(0.004
$\overline{g}_{i,t}$	0.523^{***}	0.498^{***}	0.109^{*}	0.499^{***}	0.108^{*}
	(0.104)	(0.106)	(0.058)	(0.106)	(0.058)
$\overline{g}_{-i,t}$			0.718^{***}		0.718^{***}
			(0.106)		(0.106)
$e(t-4)_{ic,t}$				0.002	-0.003^{*}
				(0.003)	(0.002)
$e(t-3)_{ic,t}$				0.007^{*}	-0.007^{**}
				(0.004)	(0.002)
$e(t-2)_{ic,t}$				0.008^{*}	-0.004
				(0.004)	(0.003)
$e(t-1)_{ic,t}$				0.009^{*}	-0.005
				(0.004)	(0.003)
$e(t-4)_{-ic,t}$					0.002
					(0.004)
$e(t-3)_{-ic,t}$					0.006
					(0.004)
$e(t-2)_{-ic,t}$					0.008^{*}
					(0.005)
$e(t-1)_{-ic,t}$					0.007^{**}
					(0.003)
instruments			$\overline{g}_{-i,t}$		$\overline{g}_{-i,t}, \overline{\mathbf{e}}_{-i,t}$
F			45.16^{***}		11.34^{***}
(p)			(0.001)		(0.000)
H					7.41
(p)					(0.110)
obs.			16,148		
groups			1,518		

Notes: Standard errors clustered by province (75 clusters) in parentheses. Includes pair and region-year effects. IV(I): instrument is grouping variable in (19); IV(II): instruments are grouping variable in (19) and distance to election dummies in (20). F: F-test on excluded instruments; H: Hansen test of overidentifying restrictions ($\chi^2_{(4)}$); ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 8 Tax base: consolidated semi-log specification

	(1)	(2)	(3)	(4)	(5)
	OLS	IV	first stage	IV	first stage
$\nabla R_{i,t}$	-0.007	-0.019***			
	(0.004)	(0.005)			
$\nabla R_{i,t-1}$				-0.024***	
				(0.008)	
$\nabla r_{f,t}$			1.013***		
			(0.026)		
$\nabla r_{f,t-1}$					0.688***
					(0.035)
ϵ_ρ	0.006	0.015		0.020	
F			1491.51		377.42
(p)			(0.000)		(0.000)
obs.		10,131		9,242	
groups		866		839	

Notes: Estimates of the ρ coefficient from equation (21), Standard errors clustered by province (75 clusters) in parentheses. Includes municipality and region-year effects. Columns (2)-(3): contemporaneous specification, instrument is spatially differenced foreign region's tax rate; Columns (4)-(5): lagged specification, instrument is lagged spatially differenced foreign region's tax rate F: F-test on excluded instruments; ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 9 Tax base: unconstrained semi-log specification

	(1)	(2)	(3)	(4)	(5)
	OLS	IV	first stage	IV	first stage
$\nabla r_{i,t}$	0.002	-0.188***			
	(0.009)	(0.054)			
$\nabla r_{i,t-1}$				-0.276***	
				(0.086)	
$\nabla r_{c,t}$	-0.018***	-0.019***		-0.016**	
	(0.005)	(0.005)		(0.006)	
$\nabla \overline{g}_{-i,t}$			0.493***		
			(0.079)		
$\nabla \overline{g}_{-i,t-1}$					0.423***
					(0.078)
ϵ_{λ}	0.001	0.040		0.058	
ϵ_{ϕ}	0.004	0.004		0.003	
F			38.69		29.37
(p)			(0.000)		(0.000)
obs.		10,055		9,185	
groups		848		848	

Notes: Estimates of the λ and ϕ coefficients from equation (22). Standard errors clustered by province (75 clusters) in parentheses. Includes municipality and region-year effects. F: F-test on excluded instruments; ***: p-value $<$ 0.01; **: p-value $<$ 0.05; *: p-value $<$ 0.10.

Table 10 Tax base: consolidated double-log specification

	(1)	(2)	(3)	(4)	(5)
	OLS	IV	first stage	IV	first stage
$\nabla \ln(R_{i,t})$	-0.016* (0.009)	-0.048*** (0.011)			
$\nabla \ln(R_{i,t-1})$				-0.053*** (0.018)	
$\nabla \ln(r_{f,t})$			0.799*** (0.021)		
$\nabla \ln(r_{f,t-1})$					0.524*** (0.022)
F			1379.06		540.02
(p)			(0.000)		(0.000)
obs.	10.131			9,242	
groups	866			839	

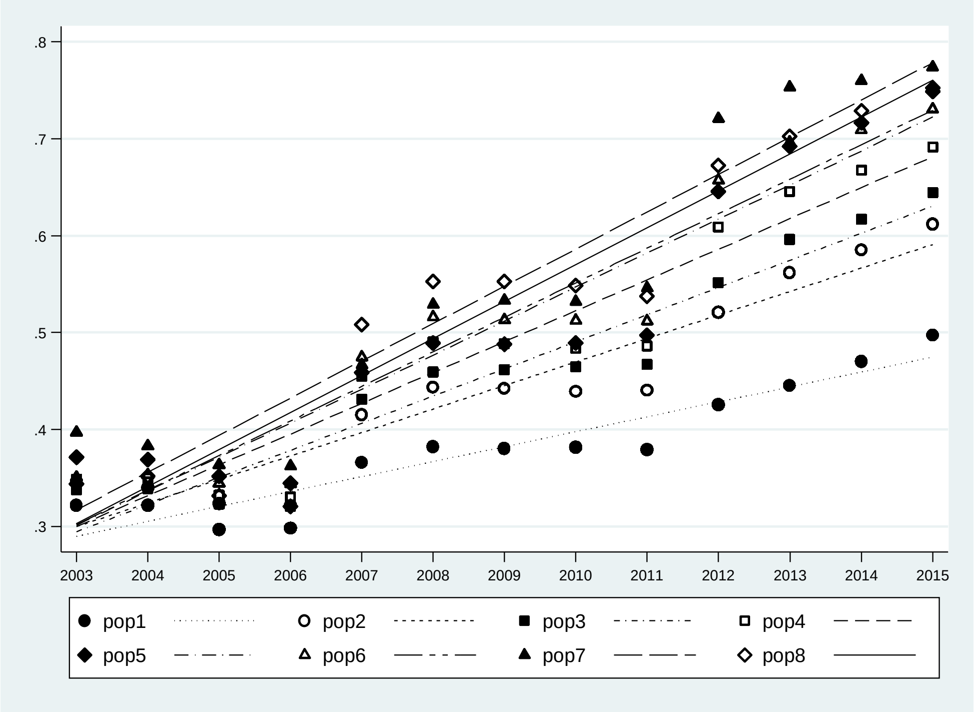
Notes: Estimates of ϵ_ρ from equation (23). Standard errors clustered by province (75 clusters) in parentheses. The equation includes municipality and region-year effects. Columns (2)-(3): contemporaneous specification, instrument is spatially differenced log foreign region's tax rate; Columns (4)-(5): lagged specification, instrument is spatially differenced lagged log foreign region's tax rate; ***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.10.

Table 11 Tax base: unconstrained double-log specification

	(1)	(2)	(3)	(4)	(5)
	OLS	IV	first stage	IV	first stage
$\nabla \ln(r_{i,t})$	0.001	-0.086***			
	(0.003)	(0.028)			
$\nabla \ln(r_{i,t-1})$				-0.126***	
				(0.040)	
$\nabla \ln(r_{c,t})$	-0.037***	-0.033***		-0.026**	
	(0.009)	(0.010)		(0.012)	
$\nabla \ln(\overline{g}_{-i,t})$			0.432***		
			(0.102)		
$\nabla \ln(\overline{g}_{-i,t-1})$					0.380***
					(0.090)
F			22.07		17.81
(p)			(0.000)		(0.000)
obs.		10,055		9,185	
groups		848		848	

Notes: Estimates of ϵ_λ and ϵ_ϕ from equation (24). Standard errors clustered by province (75 clusters) in parentheses. The equation includes municipality and region-year effects. Columns (2)-(3): contemporaneous specification, instrument is spatially differenced log grouping variable; Column (4)-(5): lagged specification, instrument is spatially differenced lagged log grouping variable; ***: p-value $<$ 0.01; **: p-value $<$ 0.05; *: p-value $<$ 0.10.

Figure 1 Trajectories of tax rate grouping instruments by demographic group



Notes: Growth of the grouping instrumental variable (top municipal income tax rate) by demographic brackets: pop1: population<1,000; pop2: 1,000<population<3,000; pop3: 3,000<population<5,000; pop4: 5,000<population<10,000; pop5: 10,000<p<15,000; pop6: 10,000<p<30,000; pop7: 30,000<p<50,000; pop8: pop>50,000.