

**An empirical analysis on intergovernmental
strategic interaction in tax policy:
Evidence from capital taxation in Japan**

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Abstract

In this paper, the interrelationship between the capital tax policies of local governments is empirically investigated using a data set from Japan. Reaction functions of local governments, which relate their capital tax rates to those in competing governments and their characteristics, are estimated through both the instrumental variable method and maximum likelihood estimation. The results suggest that a positive relationship exists among local governments in Japan.

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1 Introduction

In a decentralized system, such as in domestic jurisdictions and the international community, the actions of one government are not independent of the actions of other governments. Strategic interaction is a key element in recent models of government behavior. Policy choices are thus interdependent, and the resulting interaction must be taken into account in characterizing the public sector equilibrium.

Tax competition among independent governments is one of these phenomena, which has become the focus of a growing literature in public finance. It arises when more than two taxing jurisdictions have an incentive to decrease the tax rate on mobile input to attract tax bases. A fundamental result from the theory of tax competition is that interregional tax competition for mobile capital generates fiscal externalities and tends to result in an undersupply of public goods in a region when each regional government seeks to act in the best interest of residents.¹

Such a result is tested through data from many countries including Belgium, Canada, Germany, the United Kingdom and the United States.² In

¹This result was originally modelled by Zodrow and Mieszkowski [26] and Wilson [24]. Surveys on theoretical works are provided by Wilson [25] and Fuest et al. [11]. The one on empirical research is provided by Revelli[22]. According to Wilson [25], there are two alternative views on the consequence of tax competition. One is called Tiebout's view, in which each region's government is controlled by its landowners, who seek to maximize the after-tax value of the region's land by attracting mobile firms to locate this land. In this setting, competition for mobile firm is welfare enhancing. The other is political economy model. In this view, governments are assumed to be concerned in part with maximizing the size of the public sector. In this case, tax competition again improve welfare, since the size of government would be excessive in the absence of this competition.

²Belgium: Heyndels and Vuchelen [13], Canada: Brett and Pinkse [4] and Hayashi

this paper, evidence from local governments in Japan is added to the literature. An attractive feature of my data set is its comprehensiveness. In Japan, there are two types of corporate income tax, *corporate inhabitant tax* and *business tax*. My data set includes both taxes, and so it becomes a comprehensive measure of source-based capital taxation, which is important in the literature to the theory of tax competition.

In the empirical investigation, observed tax rates are regressed on various local characteristics of potential influence according to the theoretical model. The tax policy of possibly competing jurisdictions is taken into account. Yet, in order to take account of the simultaneity of the observed taxing decisions, (a) predetermined or exogenous determinants of tax rates are used as instruments of neighbors' tax policy by means of a spatial instrumental variables technique, or (b) maximum likelihood estimation is conducted.

The layout of the rest of the paper is as follows. Section 2 presents the theoretical background which supports the empirical specification in this paper. Section 3 provides the empirical methodology. Section 4 presents data, specifically original panel data on the effective capital tax rate of Japanese prefectures. Section 5 explains the results of regression, and Section 6 briefly concludes.

and Boadway[12], Germany: Buettner [7], United Kingdom: Revelli [21], United States: Brueckner and Saavedra [5] and Rork [23]. Also, an analysis in the context of international competition is in Devereux, Lockwood and Redoano [9]. The results from the previous literature is summarized in Table 4.

2 A Theoretical Framework

2.1 The model³

Production. The production in prefecture i is provided by $f(k)$ with $f'(k_i) > 0$ and $f''(k_i) < 0$, where k_i is the capital invested in this prefecture. Each prefecture produces a single consumption good whose price is normalized to unity. This consumption good can either be consumed directly as a private commodity, x_i , or be used to provide the regional public service, g_i . One unit of the private good produces one unit of public service.

The prefecture levies a source tax at rate τ_i on each unit of capital employed within the prefecture.

A perfect mobile capital implies:

$$f'(k_i) - \tau_i = r, \quad (1)$$

for all i , where r is the after-tax rate of return on capital. Equation (1) is written as $k_i = k_i(\tau_i, r)$ with $\partial k_i / \partial \tau_i < 0$ since $f'(k_i)$ is monotonic decreasing in k_i .

Market clearing condition for capital is:

$$\sum_{i=1}^n k_i = \sum_{i=1}^n \bar{k}_i, \quad (2)$$

³The model explained here is a simplified version of that in Brueckner and Saavedra [5].

where \bar{k}_i is capital endowment of the residents of prefecture i and n is the number of prefectures.

Individuals. Let $U_i(x_i, g_i)$ denote the utility function for homogeneous individuals who reside in prefecture i . They are assumed to be homogeneous. Consumer income is the sum of the following components: the return to the fixed factor, $w_i = f(k_i) - k_i f'(k_i)$, which is interpreted as wage income; the return to the capital endowments $r\bar{k}_i$. Thus, their budget constraint is as follows:

$$x_i = f(k_i) - k_i f'(k_i) + r. \quad (3)$$

Government. Prefectures finance the provision of a public good through a source-based corporation tax levied on the profit of firms. That is, the government budget constraint in each region implies:

$$g_i = \tau_i k_i. \quad (4)$$

Using (3) and (4), utility can be written:

$$U_i(f(k_i) - k_i f'(k_i) + r\bar{k}_i, \tau_i k_i). \quad (5)$$

The government is assumed to be benevolent, and so it sets τ_i to maximize the utility of residents (5). Differentiating (5) with respect to τ_i , and using (1), the first-order condition is:

$$\frac{U_{ig}}{U_{ix}} = \frac{k_i + (k_i - \bar{k}_i) \frac{\partial r}{\partial t_i}}{k_i + t_i \frac{\partial k_i}{\partial t_i}}, \quad (6)$$

where U_{ig} and U_{ix} are marginal utilities with respect to z and x .⁴

2.2 Reaction Functions

Because estimation of reaction functions is the goal of the empirical work, it is useful to derive these functions for a special case. First, suppose for simplicity that $n = 2$ and endowments of capital are the same across prefectures, $k_i = k_j = \bar{k}$. Also, suppose f is quadratic and preference is linear, with $f(k_i) = \beta k_i - \gamma k_i^2/2$ and $U_i = x_i + \eta_i z_i$, where $\beta, \gamma, \eta > 0$. Then, (1) and (2) yield $k_i = \bar{k} + (t_j - t_i)/2\gamma$ for $i \neq j$, so that $\partial k_i / \partial t_i = -1/2\gamma$. Substituting these results in (6), the equation can be solved to yield prefecture i 's reaction function:

$$\tau_i = \frac{2\gamma(1 - \eta_i)\bar{k} + (1 - \eta_i)\tau_j}{(1 - 2\eta_i)}. \quad (7)$$

The slope of reaction function, which is equal to $(1 - \eta_i)/(1 - 2\eta_i)$, is positive when $\eta_i > 1/2$ and negative when $\eta_i < 1/2$. Thus, prefecture i raises (lowers) its tax rate in response to an increase in τ_j when marginal utility of the public good is large (small).

⁴Evaluating (6) in the symmetric case, where consumers have identical preferences and capital endowment, $\tau_i = \tau_j$ must hold in the Nash Equilibrium for all i and j , implying $k_i = k_j = \bar{k}_i = \bar{k}_j$. The right hand side of (6) reduces to $k_i/[k_i + t_i(\partial k_i / \partial t_i)] > 1$, recalling $\partial k_i / \partial t_i < 0$. Since the marginal rate of transformation between the private and public goods is unitary, this inequality implies g is under-provided.

3 Empirical Strategy

3.1 Model Specification

As seen above, the model generates reaction function, which relate each prefecture's chosen source-based capital tax rate τ to its own characteristics and to the choice of other prefectures. A simple empirical version of (7) may be written as:

$$\tau_{i,t} = \rho \sum_{j \neq i} w_{ij} \tau_{j,t} + x'_{i,t} \theta + \mu_i + \lambda_t + \epsilon_{i,t}, \quad (8)$$

for $i = 1, \dots, n$ and $t = 1, \dots, T$, where i and t are the index of prefecture and year, w_{ij} represents a set of time-invariant weights that aggregate the tax rate in other prefectures into a single variable, which has a scalar coefficient ρ . Note that the sum of w_{ij} across j is assumed to be unity.

The vector x_{it} contains the socio-economic characteristics of prefecture i , which represent preferences and other factors affecting the setting for public goods. θ is the corresponding coefficient vector, while μ_i denotes the prefectural specific fixed effect, such as time invariant unobservable preference of residents. λ_t denotes the time period specific fixed effect, such as nationwide policy change and economic fluctuations. It is assumed that ϵ_{it} is normally distributed with constant variance and is independent across observations. Note that (8) may be viewed as a linear approximation to a more general nonlinear reaction function.

Repeating (8) for each prefecture, the equation can be rewritten in matrix form as:

$$\tau = \rho W\tau + \theta X + Z_\mu\mu + Z_\lambda\lambda + \epsilon = \rho W\tau + Z\delta + \epsilon, \quad (9)$$

$$\epsilon \sim N(0, \sigma^2 I_{NT}),$$

where

$$\tau = [\tau_{11}, \dots, \tau_{1T}, \dots, \tau_{N1}, \dots, \tau_{NT}]',$$

and

$$X = [X_{11}, \dots, X_{1T}, \dots, X_{N1}, \dots, X_{NT}]',$$

are a $NT \times 1$ vector and a $NT \times K$ matrix with the observations stacked so that the slower index is over prefectures and the faster index is over time. K is the number of control variables. $W = I_T \otimes W_N$, where W_N is a $N \times N$ spatial weighting matrix, which is explained in section 3.3. $Z_\mu = \iota_T \otimes I_N$ and $Z_\lambda = I_T \otimes \iota_N$ are matrices of dummy variables to capture prefecture and time fixed effects respectively, where ι_{nT} is a $NT \times 1$ vector of ones.⁵ $\mu = [\mu_1, \dots, \mu_N]'$ is a vector of dimension $N \times 1$. $\lambda = [\lambda_1, \dots, \lambda_T]'$ is a vector of dimension $T \times 1$. $\epsilon = [\epsilon_{11}, \dots, \epsilon_{1T}, \dots, \epsilon_{N1}, \dots, \epsilon_{NT}]'$ is a $NT \times 1$ vector of error term, $Z = [X, Z_\mu, Z_\lambda]$, $\delta' = [\theta', \mu', \lambda']$.

⁵Typically speaking, the form of time dummies is $Z_\lambda = \iota_N \otimes I_T$ instead of $Z_\lambda = I_N \otimes \iota_T$ in literature on panel analyses (for example, Baltagi [3]), since the observations stacked in such a way that the slower index is over time and the faster index is over individual.

3.2 Identification Issue

3.2.1 The problem

The model predicts that all tax rates are jointly determined, indicating endogeneity of τ . As a result, the linear combination of the τ_i , $W\tau$, appearing on the right-hand side of (9) is endogenous and correlated with ϵ . Accordingly, the OLS of (9) does not generate a consistent estimator.

When viewed formally, (9) can be used to solve for the equilibrium values of the τ . Given $(I_{NT} - \phi(I_N \otimes W))$ is non-singular, (9) yields the reduced form as:

$$\tau = (I_{NT} - \rho W)^{-1} Z\delta + (I_{NT} - W)^{-1} \epsilon,$$

and so:

$$W\tau = W(I_{NT} - \rho W)^{-1} Z\delta + W(I_{NT} - \rho W)^{-1} \epsilon, \quad (10)$$

which implies the violation of a classical assumption for OLS:

$$E[(W\tau)\epsilon'] = W(I_{NT} - \rho W)^{-1} E(\epsilon\epsilon') = \sigma^2 W(I_{NT} - \rho W)^{-1} \neq 0,$$

that is, in general, $W\tau$ is correlated with the disturbance vector ϵ . The resulting correlation means that OLS estimates of the parameters of (8) (and (9)) are inconsistent, requiring the use of an alternate estimation method.

According to Brueckner [6], Reveli [22], and Anseline [1], two methods are used to address this econometric problem in the literature.

The first method is an instrumental variables (IV) approach. Under the second method, the reduced-form equation given by (9) is estimated using the maximum likelihood (ML) estimation method. It is known that both methods yield consistent estimates of the parameters of (9). In this paper, both estimations are conducted. Detailed explanations of both methods are provided below⁶.

3.2.2 Instrumental variable method⁷

First, we use a type of instrumental variable approach, a feasible generalized spatial two-stage least square procedure proposed by Kelejian and Prucha [15]⁸. Instrumental variable is based on the idea of removing the bias-generating correlation between the endogenous regressor $W\tau$ and the error term ϵ by using neighbors' exogenous variables (Z) as instruments.

In Kelejian and Prucha [15], the consistent estimator of $[\rho, \delta']$ is derived formally and the selection of instruments is couched in terms of the reduced form (10). From (10), it follows that:

$$E[W\tau | Z] = W(I_{NT} - \rho W)^{-1}Z\delta.$$

⁶The survey of these methods are provided by Anseline [1, 2], Elhorst [10] and Lee and Yu [16].

⁷This subsection owes to Anseline [1].

⁸The literature, including Devereux, Lockwood and Redoano [9] and Brueckner and Saavedra [5] utilized this procedure.

With $|\rho| < 1$, the following expansion holds:

$$E[W\tau | Z] = Z\delta + \rho WZ\delta + \rho^2 W^2Z\delta + \dots$$

Based on this expansion, Kelejian and Prucha [15] suggest the use of a subset of columns from $\{Z, WZ, \dots, W^qZ\}$, where, typically, q is set as $q \leq 2$ (Piras [19]), as the instruments. Hence, in this paper, $H = [Z, WZ, W^2Z]$ is used as the instrument.

Using H as the instrument, a two stage least square estimation is conducted. That is, consider model (9) rewritten as:

$$\tau = V\gamma + Z_\mu\mu + Z_\lambda\lambda + \epsilon, \quad (11)$$

where $V = [W\tau, X]$, and $\gamma = [\rho, \theta']$.

In the first stage, the predicted value of V in a regression on the instrument is obtained as:

$$\hat{V} = H(H'QH)H'QV,$$

where Q denotes the demeaning operator in matrix form:

$$Q = (I_{NT} - \frac{1}{T}\iota_T\iota_T' \otimes I_N)(I_{NT} - I_T \otimes (\frac{1}{N}\iota_N\iota_N')),$$

and ι_T and ι_N are vectors of those whose subscript denotes the length of this vector.

In the second stage, \hat{V} replaces V , resulting in the spatial two stage least

square estimator:

$$\hat{\gamma}_{IV} = (\hat{V}'Q\hat{V})^{-1}\hat{V}'Q\tau. \quad (12)$$

3.2.3 Maximum likelihood estimator⁹

According to Elhorst [10], the log-likelihood for the spatial lag model (9) follows as:

$$L = -\frac{NT}{2} \ln(2\pi\sigma^2) + T \ln |I_{NT} - \rho W| - \frac{1}{2\sigma^2} (\tau - \rho W\tau - Z\delta)' (\tau - \rho W\tau - Z\delta). \quad (13)$$

The analytical solution for $\hat{\gamma}$ is as follows:

$$\hat{\gamma}_{MLE} = (X'QX)^{-1}XQ(I_{NT} - \rho W)\tau, \quad (14)$$

3.3 Specification of the weighting matrix

This paper focuses on two common approaches: contiguity weights and output-contiguity weights. A contiguity weight treats each bordering observation equally. An output-contiguity weight still assumes that the relevant observations are only those that border the observation. In this case, however, weights are based on the output of the bordering observations. As is

⁹This subsection owes to Elhorst [10]. Equations (13) and (14) are taken from the equations (C.2.26a) and (C.2.28) in Elhorst [10] respectively.

common in the literature, we use row-standardized weights, meaning the sum of the weights equals one.

4 Data

4.1 The effective tax rate

4.1.1 Mendoza's method

The tax rate measure used in this paper is based on the ratio of tax payments to a measure of the operating surplus of the economy, proposed by Mendoza et al. [17]. They used data on tax revenues from the OECD's *Revenue Statistics* and data on income and expenditures from the OECD's *National Account of OECD countries*. They present a series of effective tax rates on consumption, labor, and capital for seven OECD countries for the period 1965-1996. By their method, the effective tax rate on capital is defined by:

$$\tau_k = \frac{T_{1200} + T_{4100} + T_{4400} + \tau_h(OSPUE + PEI)}{OS}, \quad (15)$$

where $T_{1200} + T_{4100} + T_{4400}$ are taxes paid directly out of capital income or wealth to capital income: T_{1200} is the revenue from taxes on income, profits, and capital gains of corporations; T_{4100} is the revenue from recurrent taxes on immovable property; and T_{4400} is the revenue from taxes on financial and capital transactions. These four digit numbers are the classification codes for international comparison defined by the OECD's *Revenue Statistics*, and

so these data are taken from it.

The revenue from the capital income tax on individuals is $[\tau_h(OSPUE + PEI)]$; τ_h is household's average tax rate on total income defined as below; $OSPUE$ is operating surplus of private unincorporated enterprises; PEI is household's property and entrepreneurial income, and OS is the total operating surplus.

The household's average tax rate on total income, τ_h , is defined by:

$$\tau_h = \frac{T_{1100}}{OSPUE + PEI + W},$$

where T_{1100} is the taxes on income, profits, and capital gains of individuals, W is wages and salaries. Data on income such as OS , $OSPUE$, PEI , and W are taken from the OECD's *National Account of OECD countries*.

The right hand side of (15) represents the difference between post-tax and pre-tax capital income divided over pre-tax capital income, which is consistent with the tax distortions faced by a representative agent.

4.1.2 Application to prefectures in Japan

The above method is applied to calculate the effective tax rate on capital of prefectures in Japan. According to the OECD's *Revenue Statistics*, *corporate inhabitant tax* and *business tax* are classified as T_{1200} (the revenue from taxes on income, profits, and capital gains of corporations), *prefectural property tax* is classified in T_{4100} , and *real property acquisition tax* is classified in T_{4400} .

Data on revenue from these tax units is taken from the Ministry of Internal Affairs and Communications, Japan, *Settlement Cards*. Data on income such as *OS*, *OSPUE*, *PEI*, and *W* are taken from the Cabinet Office, Japan, *Annual Report on Prefectural Accounts*. These data sources are available for fiscal years 2001-2008 and 1955-2007, respectively, and so the effective tax rate is calculated for fiscal years, 2001-2007.

The most favorable feature of this method is its comprehensiveness as the measure of tax burden on capital. It takes into account the net effect of existing rules regarding credits, exemptions, and deductions¹⁰. Also, Mendoza et al. [17] reports tax rates calculated by their method are within the range of *marginal* tax rates and display very similar trends, despite that these measures are essentially *average* tax rates.

On the other hand, it is to be noted that this measure can vary according to economic conditions, even when tax regimes do not change. Since this paper is interested in examining the tax changes as the outcomes of policy change, the employment of this measure may possibly not be appropriate unless we control for non-policy elements. Variables that are expected to influence this measure should be included in the vectors of exogenous variables as explained below.

¹⁰Hayashi and Boadway [12] used a similar average tax rate approach. They calculate the ratio of tax revenue from corporate tax and operating surplus of states and federal governments in Canada.

4.2 Control Variables

The control variables for tax rates can be thought of as including several types. First, I control for factors that affect the demand for public expenditure. I include the fraction of the population over 65 years old, which may increase the demand for public spending according to Razin et al. [20]. They construct the model to analyze the effect of aging on capital income taxation. An older person typically has a mixed attitude toward the benefits from public expenditure, when they are financed by capital taxes, since their income is derived mostly from capital. The majority-voting model, in which tax competition is not considered, predicts tax rates on capital income could actually rise as the population ages, even though older individuals would be expected to own more capital than the young and thus, vote against higher taxes. Razin et al. [20] also provide empirical evidence to support this prediction with the data from a panel of ten EU countries.

In addition, I include a measure of asset and income inequality — the Gini coefficient of asset and income. The Gini coefficient is a measure of the inequality of a distribution, where a value of 0 expresses total equality and a value of 1, maximum inequality. These variables — denoted as the “the skewness of asset” and “the skewness of income” — have been used in previous theories that attempt to explain the size of the governments. Persson and Tabellini [18] provide a political economy model that predicts that higher income inequality leads to higher public expenditure, in which tax competition is not considered. Ihori and Yang [14] provide a political

economy model with tax competition which predicts that higher asset inequality leads to a higher capital tax rate. Although the prediction of the effect of these variables are clear-cut as explained, the availability of actual data is limited. Prefectural data of the Gini coefficient of asset and income are available for only once a five year period. Accordingly, data for 1999 and 2004 are regarded as those for 2001-2003 and 2004-2007, respectively in the estimation.

The next type of variable is meant to control for factors that affect the prefecture's need for revenue. Untied grants from the central government are included, which may decrease the need for revenue, since such grants may lower the need for finance by themselves.

The final type controls for factors that affect direct tax payments of businesses. As explained above, the effective tax rate will typically change if corporate profits change, even when policy does not change. Hence, the ratio of loss-making business is included, since their tax payments are considerably limited. The previous literature on tax competition also includes variables to control tax payments of businesses. For example, Hayashi and Boadway [12] include a capital utilization rate and GDP growth rate; Buettner [7] include income tax revenue; Revelli [21] includes tax base per head and unemployment rate; Brueckner and Saavedra [5] include per capita income.

The source of the control variables is explained in Table 1. The descriptive statistics for the effective tax rate and control variables are provided in Table

Table 1: Data sources

Variable	Description	Source
Capital tax rate	Effective tax rate on capital, defined by the ration of tax revenue and output, Mendoza et al. [17]	Calculated by the author
Proportion old	Proportion of population above 65 years old	Ministry of Internal Affairs and Communications, Japan, <i>Demographic Statistics</i>
Asset skewness	Gini coefficient of savings of households	Ministry of Internal Affairs and Communications, Japan, <i>National Survey of Family Income and Expenditure</i>
Income skewness	Gini coefficient of yearly income of households	Ministry of Internal Affairs and Communications, Japan, <i>National Survey of Family Income and Expenditure</i>
Untied grant per head	Untied grant from central government (Local Allocation Tax) per population (thousand yen)	Ministry of Internal Affairs and Communications, Japan, <i>Annual Statistics on Local Public Finance</i>
Proportion loss-making business	Proportion of corporations in deficits	National Tax Agency, Japan, <i>Annual Statistics Report</i>

2.

5 Results

The estimation of (9) is performed on the effective capital tax rate of all 47 prefectures in Japan for the financial years 2001-2007. The method exploited here is instrumental variable (IV) regression and maximum likelihood (ML) estimation, which are explained in Section 3.2. That is, IV and ML estimators

Table 2: Descriptive statistics

Variable	Mean	St.Dev	Min	Max
Capital tax rate	0.038	0.011	0.022	0.081
Proportion old	0.216	0.030	0.135	0.286
Asset skewness	0.536	0.026	0.464	0.654
Income skewness	0.299	0.014	0.275	0.353
Untied grant per head	72.8	34.0	17.9	209.3
Proportion loss-making business	0.696	0.037	0.605	0.782

are given in (12) and (14), respectively.

The results are presented in Table 3. This table contains three columns (1 to 3) with the uniform contiguity scheme as the weighting matrix and three columns (4 to 6) with the output contiguity scheme as the weighting matrix. For each form of weighting matrix, results are based on two estimation methods: (a) instrumental variable estimation, and (b) maximum likelihood estimation. Note that, in general, the choices of weighting schemes and estimation methods bring little change to the results.

For the tax rate, there is clear evidence of an effect of other prefecture' tax rate. The size of the coefficient varies from 0.255 to 0.487; that is a one percentage point increase in the average that other prefecture' statutory tax rates would tend to increase the rate in prefecture by between 0.255 to 0.487. These figures are statistically significant in any weighting schemes and estimation methods.

When considering the control variables, the proportion of older people is positive, as expected, but not significant. Asset and Income skewness are negative and statistically insignificant, which is inconsistent with the

Table 3: Estimation results for the reaction function: Dependent variable = capital tax rate

	(1)	(2)	(3)	(4)
Weights	Uniform		Output	
Estimation method	IV	ML	IV	ML
Other prefecture's capital tax rate	0.487 (2.464)	0.318 (5.187)	0.374 (2.514)	0.255 (4.299)
Proportion old	0.000 (1.065)	0.000 (1.073)	0.000 (0.898)	0.000 (0.940)
Asset skewness	-0.015 (-1.060)	-0.016 (-1.190)	-0.017 (-1.222)	-0.017 (-1.277)
Income skewness	-0.029 (-1.136)	-0.034 (-1.479)	-0.026 (-1.045)	-0.032 (-1.376)
Untied grant per head	0.000 (0.893)	0.000 (0.840)	0.000 (0.721)	0.000 (0.711)
Proportion loss-making business	-0.044 (-2.607)	-0.051 (-3.599)	-0.050 (-3.132)	-0.054 (-3.785)
Prefecture fixed effect	yes	yes	yes	yes
Time fixed effect	yes	yes	yes	yes
R^2	0.160	0.936	0.161	0.934
Number of Observations	322	322	322	322

t-statistics appear in parenthesis.

prediction and may possibly be due to the limited availability of data as previously explained. Untied grant per head is also negative and statistically insignificant. On the other hand, the proportion of loss-making business has the expected significant negative impact on the capital tax rate.

6 Concluding remarks

The empirical question addressed in this paper is whether or not the data support the existence of tax interaction in prefectures in Japan. The reaction functions of each prefectures are estimated by both the instrumental variable method and maximum likelihood estimation. The results confirm the existence of tax externalities in the setting of capital income taxes. These results do not depend on the choice of estimation methods and weighting scheme.

On the other hand, it is difficult to ascertain the welfare consequence derived from this findings. As I discuss in section 1 and footnote 1, the effect of tax competition on welfare depends on assumptions. When each prefecture seeks to maximize the interest of residents, it is suggested that public goods are under supplied by tax competition and consequences are not efficient. While if each region's government maximize the after-tax value of the region's land, tax competition enhance welfare. Also, if government maximize the size of the public sector instead of the interest of residents, tax competition improves welfare.

Table 4: Existing literature on empirical studies regarding tax competition on capital income taxation

Literature		Data			Estimation
Author	Year	Country(-ies)	Level	Cross section / Panel	
Heyndels and Vuchelen [13]	1998	Belgium	Municipality	Cross section	IV
Brett and Pinkse [4]	2000	Canada	Municipality	Cross section	IV
Hayashi and Boadway [12]	2001	Canada	Province	Panel	SUR
Revelli [21]	2001	United Kingdom	Municipality	Cross section	IV
Brueckner and Saavedra [5]	2001	United States	Municipality	Cross section	ML
Buettner [7]	2001	Germany	Municipality	Cross section	IV
Rork [23]	2003	United States	State	Panel	IV
Buettner [8]	2003	Germany	Municipality	Panel	IV
Devereux, Lockwood and Redoano [9]	2007	OECD	Nation	Panel	IV

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Matlab code for the estimation

```
%% setup clear all; A=csvread('competition_46.csv');
W1=csvread('weight_jpref_contiguity_46.csv');
% -----
% written by: Atsushi Kawamoto
% Syracuse University and Ministry of Finance, Japan
% atsushi.kawamoto@gmail.com
%
% This code is partly based on demo files
% by J.Paul Elhorst, University of Groningen
%
% -----
% dimensions of the problem
T=7; % number of time periods
N=46; % number of regions: excluding Okinawa
% row-normalize W
W=normw(W1); % function of LeSage
y=A(:,[11]); % column number in the data matrix that corresponds
% to the dependent variable
x=A(:,[3,6,7,8,10]);
% column numbers in the data matrix that correspond
% to the independent variables
%
```

```

z1=A(:,[8]);

% column numbers in the data matrix that correspond
% to the independent variables
xconstant=ones(N*T,1);

[nobs K]=size(x);
W2=kron(eye(T),W);

% -----

%% pooled OLS
results=ols(y,[xconstant W2*y x]);
vnames=strvcat('tax','constant',
'weighted_tax','old','asset_gini','income_gini',
'untied_grant','loss_making');
prt(results,vnames,1);

% -----

%% Panel FE with time and prefecture fixed effect
% fixed effects, within estimator % demeaning of the y and x variables
x1=[W2*y x];
model=3;

[ywith,xwith,meanny,meannx,meanty,meantx]=demean(y,x1,N,T,model);
results=ols(ywith,xwith);
vnames=strvcat('tax', 'weighted_tax','old','asset_gini',
'income_gini','untied_grant','loss_making');
prt_reg(results,vnames);

```

```

clear x1;

%% pooled 2SLS

wx=W2*x;

wy=W2*y;

model=0;

[ywith,xwith,meanny,meannx,meanty,meantx]=demean(wy,wx,N,T,model);

results=ols(ywith,xwith);

wy_hat=results.yhat;

model=0;

[ywith,xwith,meanny,meannx,meanty,meantx]=demean(y,[wy_hat x],N,T,model);

results=ols(ywith,xwith);

vnames=strvcat('tax', 'weighted_tax','old','asset_gini','income_gini',

'untied_grant','loss_making');

prt_reg(results,vnames);

%% panel FE 2SLS with time and prefecture fixed effect

wx=W2*x;

wy=W2*y;

model=3;

[ywith,xwith,meanny,meannx,meanty,meantx]=demean(wy,[W2*wx wx x],N,T,model);

results=ols(ywith,xwith);

wy_hat=results.yhat;

model=3;

[ywith,xwith,meanny,meannx,meanty,meantx]=demean(y,[wy_hat x],N,T,model);

```

```

results=ols(ywith,xwith);
vnames=strvcat('tax', 'weighted_tax','old','asset_gini',
'income_gini','untied_grant','loss_making');
prt_reg(results,vnames);
% -----
%% MLE
info.lflag=0; % required for exact results
info.model=3;
info.fe=0; % no print intercept and spatial fixed effects
results=sar_panel_FE(y,x,W,T,info);
vnames=strvcat('tax','old','asset_gini','income_gini',
'untied_grant','loss_making'); prt(results,vnames,1);

```