ISSN: 2039-4004

department of economics
"S. Cognetti de Martiis"

Via Po, 53 – 10124 Torino (Italy)
Tel. (+39) 011 6704043 - Fax (+39) 011 6703895
URL: http//www.de.unito.it

WORKING PAPER SERIES

BUSINESS TAXATION AND ECONOMIC PERFORMANCE IN HIERARCHICAL GOVERNMENT STRUCTURES

Federico Revelli

Dipartimento di Economia “S. Cognetti de Martiis”

Working paper No. 04/2012

Università di Torino

Business taxation and economic performance in hierarchical government structures

Federico Revelli*
University of Torino

April 10, 2012

Abstract

This paper models theoretically and investigates empirically the consequences on local economic performance of state mandates on financially distressed authorities. In particular, I analyze the switch from systematic state bailout of regional health care deficits to selectively mandated hikes in regions' own business income tax rates that took place in Italy around the mid 2000s, and exploit such dramatic switch to identify the impact of tax policy on the economy. I model factor input use within a multi-jurisdiction neoclassical framework, where production takes place in plants, and physical capital requires energy in fixed proportions depending on the size of energy-saving capital that is installed along with physical capital. Energy-saving capital can be interpreted either as tangible information technology (IT) equipment (*e.g.*, computer-aided line speed control devices) or as intangible assets (*e.g.*, process design skills) lowering a plant energy requirement. The estimation results based on panel data for the Italian provinces and regions over a decade (2000-2010) reveal that, by raising the user cost of capital, mandated business income tax hikes stimulate province-level business energy use, lending support to the hypothesis of short run substitution between energy and energy-saving capital, and hamper the employment of human resources in science and technology (S&T) occupations, the latter being interpretable as a proxy for energy-saving capital.

JEL codes: H25; H71; H73; Q48; R12

Key words: business income tax; state mandates; energy tax; energy use

*Department of Economics, University of Torino, Via Po 53, 10124 Torino (Italy); e-mail: federico.revelli@unito.it.

1 Introduction

The late 2000s saw a dramatic deterioration of local government budgets across Europe, with the mounting local hidden debt issue raising doubts about the success of announced fiscal austerity and international rescue programs (European Central Bank, 2011; Lojsch, Rodriguez-Vives and Slavik, 2011). Amongst Southern European countries, the sudden worsening of Portugal budget figures towards the end of 2011 was partly due to the emergence of extensive local government financial distress, with the small island of Madeira alone disclosing a spectacular debt of over €6 billion.[1] In Spain, regional governments account for over a third of public spending as well as of national public deficit, and had their debts doubled during the financial crisis, with large autonomous communities like Catalonia systematically overshooting their deficit targets and forcing central government to impose quarterly budget reporting (Ministry of Finance and Public Administration, 2011).[2]

In Italy, economic growth slowdown and nationwide fiscal consolidation policies posed a threat on the sustainability of regional governments' finances. In spite of the profound reforms of the regional revenue raising structure that took place between the late 1990s and early 2000s, the terms of the financial relationship between the state and the regions remained opaque, deepening the soft budget constraint problem and generating unprecedented regional deficit figures in the subsequent years. In fact, systematic under-funding of regional authorities, creation of budget deficits, and unconditional ex post financial intervention (bailing out) on the part of the state were recurrent and almost structural features of the system of state-region relationships in Italy until the mid 2000s. However, the release, after the 2005 nationwide regional elections, of sensational data on the debt accumulated over the latest terms of office in a number of regions, finally led the state government to mandate increases in regional own tax rates in order to have the burden of debt recovery fall onto those regions' taxpayers. In particular, the regional business income tax rate - an origin based net income-type value added tax on all business activities - increased by state command by one percentage point in 2007, with further mandated rate increases following into regions that were not complying with the agreed upon fiscal consolidation plans.

The objective of this paper is to investigate the effects of centrally mandated tax increases on local economic performance. To what extent decentralized tax policy influences business location, investment, employment and output growth has long been debated in the theoretical and empirical literature. The early empirical evidence based on longitudinal observations at fairly large spatial units - US states - typically failed to unveil a large impact of taxes on economic performance, fueling skepticism about the ability of tax breaks and investment tax credits alone to stimulate state economic development (Bartik, 1985). However, it is by now well known that empirical research into the impact of tax policy on economic activity is plagued by endogeneity problems making it prohibitive to

[1] "Portugal dealt blow over budget goal," *Financial Times*, October 4, 2011.

[2] "Hidden debt raises Spain bond fears," *Financial Times*, May 16, 2011.

estimate the effect of taxes on the economy correctly. Given that fiscal policy is determined by current or prospective economic conditions, macro approaches relying on administrative data require exogenous sources of policy variation in order to identify the causal effect of public policy on the economy (Barro and Redlick, 2011).

The policy endogeneity problem has been recently tackled by recurring to spatial discontinuities at borders using smaller spatial aggregates such as the US counties (Holmes, 1998; Chirinko and Wilson, 2008). Moreover, thanks to the increasing availability of large micro datasets on firm location and characteristics, empirical works based on geo-coded establishment information are flourishing.[3] Still, as argued in Duranton, Gobillon and Overman (2011), the likely presence of unobserved location-specific effects, establishment-specific effects, and omitted variables driving both time-varying site characteristics and local tax rates calls for an econometric approach based on spatial differencing (to deal with unobserved location-specific effects), time differencing (to deal with establishment-specific effects), and a proper set of instrumental variables to tackle the local tax policy endogeneity issue.

An alternative approach is the one advocated by Romer and Romer (2010) and applied by Cloyne (2011). The idea is to distinguish between endogenous and exogenous policy changes based on a categorization of observed discretionary policy changes that relies on the history and motivation of those tax changes - the so-called narrative record. Among the various motivations leading to a classification of a policy change as exogenous, Romer and Romer (2010: p. 770) maintain that "one particular motivation that is common and that falls into the exogenous category are tax increases to deal with an inherited budget deficit." Cloyne (2011: p. 9) classifies as exogenous the actions "enforced by external bodies." This suggests that a top-down mandate on financially distressed local authorities' own tax rates seems as close as one can get to an exogenous tax change, and is the approach that I pursue here to tackle the policy endogeneity issue in a multi-tiered, hierarchical government structure.

I first model factor input use within a multi-jurisdiction neoclassical model, where, as in Cooley, Hansen and Prescott (1995), the aggregate production function in each of a number of localities exhibits constant returns to scale in plant locations, physical capital, and labor, and where physical capital requires energy in fixed proportions depending on the size of energy-saving capital that is installed along with physical capital (Diaz, Puch and Guillo, 2004). Energy-saving capital can either be interpreted as tangible information technology (IT) equipment directly reducing the energy required to produce the final good (such as computer-aided technologies and industrial process electronic control devices), or, more generally, as intangible assets including knowledge, organizational structure, and process design skills (Brynjolfsson, Hitt and Yang, 2002). As in conventional energy use models, physical capital is assumed to be

[3] Recent examples are Devereux, Griffith and Simpson (2007), Rathelot and Sillard (2008) and Duranton, Gobillon and Overman (2011). Brulhart, Jametti and Schmidheiny (2012) study the effect of corporate taxes on firm births using panel data on new firm counts per municipality and economic sector in Switzerland.

a quasi-fixed factor moving slowly over time in response to input price changes, while energy-saving capital smoothly responds to shocks (Bresnahan, Brynjolfsson and Hitt, 2002).

By incorporating a multi-level tax structure, where the upper level (state) authority collects corporate income tax revenues and lower-level authorities (regions and localities) levy a business income tax and an excise tax on business energy use respectively, the model predicts that the regional business income tax negatively affects both forms of capital as well as the use of energy in the long run. However, energy and energy-saving capital turn out to be Allen substitutes in the short run. As for the price of energy, the local energy tax lowers the long run equilibrium levels of physical capital and energy - a conventional result in both putty-putty and putty-clay energy use models (Atkeson and Kehoe, 1999) - while its impact on energy-saving capital is ambiguous. In the short run, an higher energy price raises energy-saving capital's productivity and reduces aggregate energy use.

In order to identify the causal effect of factor input taxes on their use empirically, I exploit the regional business income tax rate increases that were mandated by the state in the Italian regions with excessive budget deficits, as well as the fact that provincial authorities directly tax energy by setting an excise tax on all business electricity uses, with the sole exemption of massive energy-intensive establishments. The estimation results based on panel data for the Italian provinces and regions over a decade (2000-2010) reveal that while mandated business income tax hikes had no effect on regional gross domestic product, they had a significant detrimental impact on employment in the service sector, and particularly on the use of human resources in science and technology (S&T) occupations, the latter being interpretable as a proxy for energy-saving capital. Moreover, it turns out that regional business income tax increases stimulate province-level business energy use, lending support to the hypothesis of short run substitution between energy and energy-saving capital. On the other hand, there is no evidence of significant fiscal spillovers across regional or provincial boundaries, suggesting that tax policy changes did not bring about any major shift of production facilities or variable factor input use to low-tax localities. Finally, provincial excise taxes on energy are found to discourage business consumption of energy, particularly in the service sector where most small and medium-sized firms are found.

Section **2** models factor input taxation by decentralized authorities in an hierarchical structure of government. The model does not tackle the political economy issue of how fiscal mandates are decided upon, nor does it discuss the relative merits of alternative, non-hierarchical state-local institutional arrangements. I will come back to these issues in the concluding section **5**. As for the remaining part of the paper, section **3** turns to illustrating the evolution of the regional deficit-bailout issue in Italy through the 2000s, and section **4** presents the results of the empirical analysis.

2 Hierarchical taxation and factor input use

2.1 Technology

Business activity is carried out in a finite number L of localities. Localities are partitioned into a set of R regions, with r and l indexing the region and the locality respectively, and $L_r \geq 1$ the number of localities in region r. Within each locality, production of a final good x takes place at a fixed number of *ex ante* identical plant locations $m_l = \overline{m}_l$. Locations in this economy constitute a fixed factor of production, and owners of locations earn positive rents (Cooley, Hansen and Prescott, 1995). In particular, a plant consists of a location, capital installed in it, and a fixed requirement of labor and energy to operate it. Let k_{lr} index the stock of physical capital that is directly employed for productive uses at a plant in locality l in region r.[4] Similarly to Atkeson and Kehoe (1999), physical capital is assumed to require energy in fixed proportions to deliver capital services. However, instead of posing the existence of a continuum of capital goods that embody an exogenously given energy intensity (an intrinsic energy type), the energy efficiency score of a production process is determined here by the size of energy-saving capital that is installed along with productive physical capital (Diaz, Puch and Guillo, 2004). Let h_{lr} index energy-saving capital having the sole role of improving the energy efficiency of a plant, such as computer-aided technologies and industrial process electronic control devices.[5] At time t, the energy requirement (ε_{lrt}) of the physical capital installed in a plant depends on its energy efficiency according to:

$$\varepsilon_{lrt} \geq \frac{\gamma}{h_{lrt}} k_{lrt} \tag{1}$$

where $\frac{\gamma}{h_{lrt}}$ indexes the energy requirement per unit of productive capital, and is an inverse function of installed energy-saving capital, while $\gamma > 0$ is a technology parameter. Any energy used in excess of $\frac{\gamma}{h_{lrt}} k_{lrt}$ is wasted.

The aggregate production function in locality l is:

$$X_{lrt} = \begin{cases} \overline{m}_l \left[\alpha_l \left(\frac{K_{lrt}}{\overline{m}_l} \right)^{\theta} \eta \right] & \text{if} \quad \varepsilon_{lrt} \geq \frac{\gamma}{h_{lrt}} k_{lrt} \text{ and } \eta_{lrt} \geq \eta \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where $\theta < 1$, and η is the fixed labor requirement, meaning that any labor employed at a plant in excess of η has zero marginal product. Total factor productivity α_l differs across localities because of time-invariant locality traits reflecting, say, the quality of institutions or the level of social capital. Aggregate production in locality l exhibits constant returns to scale in physical capital, labor and locations.

[4] Lower case denotes plant-level variables; upper case denotes locality-level variables.

[5] While energy-saving capital can be interpreted as tangible IT equipment directly reducing the energy requirement, it might lend itself to a broad human capital interpretation as discussed in section **4** below.

2.2 Tax structure and cross–steady-state input mix response

In the multi-tiered structure of government of this economy, the state, the regions and the localities set the following business-related taxes. First, realized profits paid as dividends to the location owners are taxed at the nationwide, proportional corporate income tax rate π_t. A precise definition of the corporate income tax base is given below. Regional governments set a net income-type value added tax on business income, *i.e.*, a tax on the returns to the two forms of capital net of depreciation, wage payments, and realized profits, at an *ad valorem* rate τ_{rt}. Finally, localities set an excise tax on energy at the rate μ_{lrt}. Energy is elastically supplied to each locality at price v.

Debt interest expenses and labor costs are entirely deductible from the corporate income tax base, but neither is from the regional business income tax base. Depreciation allowances can be deducted from the tax base at the homogeneous rate δ_0 for both taxes. Profits in locality l's establishments (p_{lrt}) can consequently be expressed as:

$$\begin{aligned} p_{lrt} &= \left[x_{lrt} - (v + \mu_{lrt}) \frac{\gamma k_{lrt}}{h_{lrt}} - c_{lrt}\right](1 - \pi_t - \tau_{rt}) \\ &\quad - w\eta(1 - \pi_t) - (k_{lrt} + h_{lrt})\left[(\iota + \delta) - \pi_t (\iota + \delta_0) - \tau_{rt}\delta_0\right] \end{aligned} \tag{3}$$

where ι is the real interest rate and w is the wage rate.[6] c_{lrt} is an idiosyncratic cost shock that is assumed to be deductible from corporate and value added taxes. It is independently and identically distributed across time and across locations, according to a uniform distribution on the $[\underline{c}, \underline{c} + \Delta_c]$ interval, with $\underline{c}, \Delta_c > 0$. c_{lrt} can be interpreted as capturing the cost of intermediate goods, materials, and services needed to produce x at a given plant. Productive and energy-saving capital are assumed to be supplied elastically to each locality, and to depreciate at the same rate $\delta > \delta_0$.[7]

Consider first a non-stochastic environment where $c_{lrt} = c$, a constant, and the two forms of capital smoothly adjust in response to tax policy changes, with energy use moving according to equation (1). Profit maximization at locality l's plants leads to the following first order conditions for k and h:

$$\begin{cases} \theta\alpha_l k_{lrt}^{\theta-1}\eta - v_{lrt}\dfrac{\gamma}{h_{lrt}} = \dfrac{\iota(1-\pi_t)+\delta}{1-\pi_t-\tau_{rt}}\left[1 - \delta_0 \frac{\pi_t+\tau_{rt}}{\iota(1-\pi_t)+\delta}\right] \\ v_{lrt}\dfrac{\gamma k_{lrt}}{h_{lrt}^2} = \dfrac{\iota(1-\pi_t)+\delta}{1-\pi_t-\tau_{rt}}\left[1 - \delta_0 \frac{\pi_t+\tau_{rt}}{\iota(1-\pi_t)+\delta}\right] \end{cases} \tag{4}$$

[6] I abstract here from modelling the household sector, and assume that labor is elastically supplied at the rate w in all localities. In order to focus on the effect of tax policy changes, all pre-tax input prices are taken to be time-invariant.

[7] The supply of capital goods might be upward sloping in the short run in the presence of external costs of adjusting the capital stock (Goolsbee, 1998). However, the hypothesis that I make here of a perfectly elastic supply curve for the two forms of capital is both conventional and plausible in the context of small localities.

where $v_{lrt} = v + \mu_{lrt}$ is the after-tax energy price, and the right hand side of (4) is the conventional user cost of capital.[8]

According to the first order condition for productive capital, the net return to an additional unit of physical capital in production is made of its marginal product minus the energy cost that such unit entails given the energy-saving capital that is installed, *i.e.*, the energy requirement per unit of capital $\left(\frac{\gamma}{h_{lrt}}\right)$ times the energy price inclusive of the excise tax (v_{lrt}). Such return is equalized to the user cost of capital consisting of the compensation for lenders (ι), the true economic depreciation rate (δ), the depreciation provision for tax purposes (δ_0), and state and regional tax rates (π_t, τ_{rt}). The first order condition for energy-saving capital equates the marginal energy saving in energy price terms - *i.e.*, the energy consumption that is foregone thanks to an additional unit of h, and that is increasing in the stock of physical capital installed in the plant - to the rental cost of capital.

Consider the cross−steady-state changes in factor input use in response to tax policy changes. Following an exogenous (mandated) increase in region r's business income tax rate τ_{rt}, the user cost of capital increases. Given that both forms of capital exhibit decreasing returns, productive and energy-saving capital are driven away from region r. The Appendix proves the following:

Proposition 1 *If plant energy use is set to* $\varepsilon_{lrt} = \frac{\gamma}{h_{lrt}} k_{lrt}$*, then: (i)* $\frac{dk_{lrt}}{d\tau_{rt}} < 0$*; (ii)* $\frac{dh_{lrt}}{d\tau_{rt}} < 0$*; (iii)* $\frac{d\varepsilon_{lrt}}{d\tau_{rt}} < 0$.

The new equilibrium input mix has lower physical capital, energy-saving capital and overall energy use in region r's localities as a result of the business income tax increase. When all factors of production adjust, energy and capital are complements, mimicking the conventional long-run result of neoclassical energy use models (Pindyck and Rotemberg, 1983).

As far as energy tax policy is concerned, the Appendix proves the following:

Proposition 2 *If plant energy use is set to* $\varepsilon_{lrt} = \frac{\gamma}{h_{lrt}} k_{lrt}$*, then: (i)* $\frac{dk_{lrt}}{d\mu_{lrt}} < 0$*; (ii)* $\frac{dh_{lrt}}{d\mu_{lrt}} > 0$ *if* $\frac{k_{lrt}}{h_{lrt}} > \frac{\theta}{1-\theta}$*; (iii)* $\frac{d\varepsilon_{lrt}}{d\mu_{lrt}} < 0$.

As the price of energy increases, use of physical capital unambiguously decreases. On the other hand, energy-saving capital might either increase or decrease as a result of the energy tax shock. First, μ raises the marginal product of energy-saving equipment, pushing towards a more intense use of h. Second, h tends to diminish because less physical capital is employed. The final effect on the use of h turns out to depend on the energy intensity of production. At high energy intensity (high $\frac{k_{lrt}}{h_{lrt}}$), the former effect dominates, and the energy price increase stimulates the use of energy-saving capital. The reverse occurs at low energy intensity. Finally, as proven in the Appendix, energy use unambiguously falls in the long run as a result of the energy tax hike.

[8] By assuming constant prices for productive capital and energy-saving equipment, I can abstract from consideration of capital gains/losses on undepreciated stocks. Moreover, rental rates for physical capital and IT energy-saving equipment are assumed equal (Krusell *et al.*, 2000).

2.3 Quasi-fixed factors and short run adjustment

Consider now the short run response of factor input use to fiscal perturbations. In conventional energy use models, physical capital is taken to be a quasi-fixed factor moving slowly in response to input price changes, while energy is treated as a flexible input. In Pindyck and Rotemberg (1983) putty-putty model, the presence of capital adjustment costs coupled with the high short run complementarity between energy and capital leads to little short run response of the former to energy price shocks. In the long run, capital adjusts and so does energy, reproducing a similar capital-energy ratio and generating a large cross-sectional negative correlation between energy prices and capital. A considerable degree of short run complementarity between energy and capital is found in putty-clay models too (Atkeson and Kehoe, 1999), where a large variety of types of capital goods are combined with energy in different fixed proportions. The fact that capital goods are designed with a fixed energy intensity and that investment in each type of capital must be nonnegative delivers a low elasticity of energy use to energy price in the short run. In the long run, permanent increases in energy prices alter the mix of capital goods towards less energy-intensive types, with energy use displaying a large own price elasticity.

As for energy-saving capital, the arguments spelled out and the evidence reported in Bresnahan, Brynjolfsson and Hitt (2002), Brynjolfsson and Hitt (2000), Brynjolfsson, Hitt and Yang (2002) suggest that it ought to be treated as flexible. Indeed, since IT capital tends to be disproportionately associated with intangible assets relative to ordinary physical capital, firms might sustain adjustment costs in terms of software development, business process innovation, and workplace organizational transformation before computer capital becomes fully effective. However, it is well documented by case examples and large-sample empirical evidence that ITs are the easiest to vary of the assets in the cluster of complementary innovations (Bresnahan, Brynjolfsson and Hitt, 2002), and this hypothesis seems plausible in the context of narrowly focused energy-saving technologies.

I allow establishments to be hit by idiosyncratic cost shocks c_{lrt} having the stochastic properties defined above. Within this environment, entrepreneurs' decision on production across the available plant locations takes place in two stages: at the beginning of period t, they have to decide on physical capital installation in a locality. This occurs after observing the tax rate vector $\mathbf{z}'_{lrt} = [\pi_t \; \tau_{rt} \; \mu_{lrt}]$, but before observing the idiosyncratic shocks hitting plants. All other variables, including the size of energy-saving capital employed and the binary choice of whether a plant will actually be operated, are set in the second stage, after observing the realization of c_{lrt}. The second stage decision determines the capacity utilization rate across locality l's plants, with unprofitable plants remaining idle.

Consider the second stage plant operation decision first: upon observing the idiosyncratic shock c_{lrt}, and once k has already been installed, plant l is operated if the value of output exceeds variable input costs, *i.e.*, if net operating income

(y_{lrt}) is positive:

$$y_{lrt} \equiv (1 - \pi_t - \tau_{rt}) \left(\alpha_l k_{lrt}^{\theta} \eta - v_{lrt} \frac{\gamma k_{lrt}}{h_{lrt}} - c_{lrt} - \eta \lambda_{rt} - h_{lrt} u_{rt} \right) \geq 0 \tag{5}$$

where $\lambda_{rt} \equiv w \left(\frac{1-\pi_t}{1-\pi_t-\tau_{rt}} \right)$ is the tax-adjusted cost of labor, u_{rt} is the user cost of capital in region r, and energy saving capital is set according to:

$$v_{lrt} \frac{\gamma k_{lrt}}{h_{lrt}^2} = u_{rt} \equiv \frac{\iota(1-\pi_t) + \delta}{1 - \pi_t - \tau_{rt}} \left[1 - \delta_0 \frac{\pi_t + \tau_{rt}}{\iota(1-\pi_t) + \delta} \right] \tag{6}$$

Let c_{lrt}^* be the cutoff cost shock at which plant l just breaks even:

$$c_{lrt}^* = \alpha_l k_{lrt}^{\theta} \eta - v_{lrt} \frac{\gamma k_{lrt}}{h_{lrt}} - \eta \lambda_{rt} - h_{lrt} u_{rt} \tag{7}$$

meaning that whenever a plant has an higher cost shock than c_{lrt}^*, it will remain idle:

$$x_{lrt} = \begin{cases} \alpha_l k_{lrt}^{\theta} \eta & \text{if } c_{lrt} \leq c_{lrt}^* \\ 0 & \phantom{\text{if }} c_{lrt} > c_{lrt}^* \end{cases} \tag{8}$$

Given that c_{lrt} is uniformly distributed between $\underline{c}$ and $\underline{c} + \Delta_c$, the fraction of plants that are operated in locality l is:

$$\Pr(c_{lrt} < c_{lrt}^*) = \int_{\underline{c}}^{c_{lrt}^*} \frac{1}{\Delta_c} dc_{lrt} = \frac{c_{lrt}^* - \underline{c}}{\Delta_c} \tag{9}$$

Turn now to the first stage decision about installation of physical capital. Expected profits at locality l's establishments are:

$$\begin{aligned} & E\left[p_{lrt} | \mathbf{z}_{lrt}\right] \qquad (10) \\ = \; & E\left[y_{lrt} | \mathbf{z}_{lrt}\right] - k_{lrt}\left[(\iota + \delta) - \pi_t(\iota + \delta_0) - \tau_{rt}\delta_0\right] \\ = \; & \int_{\underline{c}}^{c_{lrt}^*} \frac{1}{\Delta_c}\left[y_{lrt} | \mathbf{z}_{lrt}\right] dc_{lrt} - k_{lrt}\left[(\iota + \delta) - \pi_t(\iota + \delta_0) - \tau_{rt}\delta_0\right] \end{aligned}$$

Using the fact that $c_{lrt}^* = \Delta_c \Pr(c_{lrt} < c_{lrt}^*) + \underline{c}$ from equation (9), the first order condition for physical capital installation is:

$$\left[\theta \alpha_l k_{lrt}^{\theta-1} \eta - v_{lrt} \frac{\gamma}{h_{lrt}} \right] \left(\frac{c_{lrt}^* - \underline{c}}{\Delta_c} \right) = u_{rt} \tag{11}$$

Equation (11) has a straightforward interpretation: the marginal return of physical capital weighted by the probability that the plant will be operated equals the user cost of capital. With physical capital determined according to (11), expected use of energy in locality l is:

$$\begin{aligned} E\left[\mathcal{E}_{lrt} | \mathbf{z}_{lrt}\right] &= \int_{\underline{c}}^{c_{lrt}^*} \frac{1}{\Delta_c} \frac{\gamma k_{lrt}}{h_{lrt}} \overline{m}_l dc_{lrt} \qquad (12) \\ &= \frac{\gamma k_{lrt}}{h_{lrt}} \overline{m}_l \Pr(c_{lrt} < c_{lrt}^*) \end{aligned}$$

Let us now see how expected energy use in locality l as defined in (12) changes in response to tax policy changes, given the level of physical capital determined in the first stage. The Appendix proves the following:

Proposition 3 *If physical capital is installed in plants according to equation (11), and plants are operated according to equation (8), then: (i)* $\frac{dE[\mathcal{E}_{lrt}|\mathbf{z}_{lrt}]}{d\mu_{lrt}} < 0$*; (ii)* $\frac{dE[\mathcal{E}_{lrt}|\mathbf{z}_{lrt}]}{d\tau_{rt}} > 0$ *if* v_{lrt} *is lower than a cutoff energy price* v^*_{lrt}*.*

An energy tax increase unambiguously lowers the use of energy in the short run. First, an higher price of energy stimulates the use of energy-saving equipment by raising its productivity (equation (6)), thereby curbing energy use. Second, equations (7) and (9) show that the fraction of plants that are operated falls. On the other hand, a shock to τ_{rt} hikes the user cost of capital and depresses the level of energy-saving capital (equation (6)), boosting energy use; however, the plant operation rate diminishes, lowering expected energy use. The former effect dominates if energy prices are low, or net operating income is high. It follows that, conditional on output, *i.e.*, for given plant utilization rate in a locality, energy-saving capital and energy are substitutes. In particular, the short run cross-price Allen elasticity of energy with respect to the user cost of capital (Atkeson and Kehoe, 1999) is:

$$\left.\frac{\frac{dE[\mathcal{E}_{lrt}|\mathbf{z}_{lrt}]}{du_{rt}}}{\frac{E[\mathcal{E}_{lrt}|\mathbf{z}_{lrt}]}{u_{rt}}}\right|_{\substack{dK=0\\dX=0}} = \frac{1}{2}\psi_{lrt} \tag{13}$$

where $\psi_{lrt} \equiv \frac{h_{lrt}u_{rt}}{v_{lrt}\varepsilon_{lrt}}$ denotes the plant-level cost of energy-saving equipment relative to the cost of energy. If, as in Diaz, Puch and Guillo (2004), we set energy expenditures at 4.6% of GDP and energy-saving capital costs at 4.3% of GDP, we obtain a short run Allen elasticity of energy use with respect to the user cost of capital of 0.467, an almost identical figure as the one estimated by Pindyck and Rotemberg (1983: p. 1074, Table 2, panel A).

3 Debts, bailouts and other failures in the Italian health service

Spending on health care constitutes the largest outlay in the Italian regions' budgets. Total regional health expenditures surpassed €100 billion in 2006, or around 7% of national GDP and over 80% of total regional spending, with an annual real growth rate systematically exceeding that of GDP in the past two decades. This brought Italy's share of GDP spent on health from significantly below the OECD average in the early 1990s to close to EU countries' average around the mid 2000s (Tediosi, Gabriele and Longo, 2009).

Since the introduction of the National Health Service (NHS) in 1978, the major indicators of population health status soared: life expectancy at birth rose by over six years in less than three decades (reaching 84 and 77 for females and males respectively by the mid 2000s), the mortality rate almost halved, and most indicators of overall health status improved significantly (Lo Scalzo et al., 2009). In the World Health Organization (WHO) World Health Report (2000), the Italian NHS ranked 2^{nd} among 191 countries with respect to health status, fairness in financial contribution, and responsiveness to people's expectations and needs. However, self-reported health conditions, satisfaction with the health care system and popular perception of its quality and efficiency consistently turned out to be among the lowest in Europe in a number of surveys (Blendon, Kim and Benson, 2001; Maio and Manzoli, 2002).

While the Italian regions have been in charge of organizing, managing and delivering health care services for over thirty years, the issue of the financing of regional health expenditures is still amply debated. In the presence of public provision of universal and mostly free of charge services at the point of consumption through the NHS regional network, significant cross-regional patient flows, and a marked north-south economic development and health status divide, it is hardly surprising that the most contentious aspects of the federal health financing system concern the degree of accountability of regional governments to their electorates and, more importantly, the role of the state in funding health and redistributing resources among regions.[9] During the late 1990s and early 2000s, the own revenue structure of the regions was deeply reformed with the aim of raising the health care budget share to be funded by own revenues (including an own business income tax and a surcharge on the national personal income tax) and fostering regional government accountability to their electorates. Moreover, the state and the regions agreed in principle on a system of rewards and sanctions to control excessive increases in expenditures and prevent the creation of budget deficits. In spite of those efforts, the terms of the financial relationships between state and regional governments remained opaque enough as to allow the soft budget constraint problem to explode in the subsequent years, and generate unprecedented levels of regional deficits.

In fact, systematic ex ante under-funding of regional authorities, subsequent generation of conspicuous budget deficits, and ex post financial intervention (bailing out) on the part of the state have been recurrent and almost structural features of the system of state-region relationships.[10] However, the deterioration of the regional budgets during the first half of the 2000s was further exacerbated by the imposition of strict state limits on the tax rates that regions could set on their own sources of revenue, and culminated in the release, after the 2005 regional elections, of sensational data on the debt levels accumulated over the latest terms of office in a number of regions. The mounting popular outrage fueled by news of malpractice, fraud and corruption episodes finally led the newly elected national government in 2006 to mandate increases in regional own tax rates in order to have the burden of fiscal consolidation fall only onto

[9] See Ferrario and Zanardi (2011) for a recent analysis of the degree of interregional redistribution and equity attained by Italy's NHS.

[10] A detailed picture of the deficit generation process by the regions is provided by Tediosi, Gabriele and Longo (2009). Bordignon and Turati (2009) explain it as the outcome of a state-regions strategic game based on expectations and credibility.

those regions' taxpayers.[11]

In particular, the regional business income tax rate - an income-type value added tax discussed in more detail below - increased by state command by one percentage point (from the baseline rate of 4.25% to 5.25% of net value added) in six financially distressed regions. In spite of a nationwide reduction of the regional business income baseline rate to 3.90% as part of a fiscal stimulus package launched in 2008, mandated rate increases followed in the subsequent years for further regions exhibiting growing deficits.[12] Moreover, the worsening budgetary prospects in four regions induced the state to mandate additional increases in the regional business income tax rate of 0.15% in 2009 and 2010. Overall, as reported in table 1, almost half of the 20 Italian regions were affected by various state-mandated tax increases. The tax hikes led to an average fiscal burden differential for businesses located in health deficit-running areas of over $\frac{1}{4}$ relative to balanced budget regions.

4 Empirical analysis

4.1 Data

I analyze the impact of state-mandated tax increases on a vector of indicators of local economic performance. As mentioned above, the major subcentral tax formally falling onto business is the regional business income tax (*IRAP*, *Imposta Regionale sulle Attività Produttive*). It is an origin based net income-type value added tax set on all firms, including self-employed activities (Bordignon, Giannini and Panteghini, 2001; Bird, 2003; Keen, 2003). The tax base is calculated annually by a direct subtraction method as the difference between gross receipts (sales revenues) and the cost of intermediate goods and services.[13] Neither labor costs nor debt interest payments are deductible, while conventional tax depreciation provisions apply to outlays for capital goods. The tax is neutral with respect to choice of organizational form, and to equity *versus* debt financing.[14] As for the tax rate, strict limitations on regional rates have existed since the introduction of the tax in 1998: until 2007, a baseline rate of 4.25% was set nationwide, and regions were allowed to vary it by one percentage point. The central rate was then uniformly reduced to 3.90% in 2008, leaving regions the possibility of increasing or decreasing it by 0.92 percentage points. However, regions made little use of their tax autonomy through the decade, in most instances renouncing altogether to purposeful tax rate policy changes.

[11] Total regional debt amounted to over €16 billion in 2005, about half of it being attributable to two regions (Lazio in central Italy and Campania in southern Italy).

[12] One region (Liguria) was allowed to come back to the baseline rate in 2008 thanks to disciplined spending behavior and credible attempts to cut deficit.

[13] Specific rules apply to financial intermediaries and insurance companies.

[14] Moreover, the tax does not discriminate between different sources of equity capital (retained earnings *versus* new subscriptions), and all profits are included in the tax base, irrespective of whether they are retained or distributed. No tax credit is given to shareholders for the tax paid by the company (Bordignon, Giannini and Panteghini, 2001).

In addition, an excise consumption tax is applied by the lower-level of government - the provinces - on business uses of electricity. The provincial level of government is made of 103 jurisdictions, whose average size roughly corresponds to that of the US counties and UK counties.[15] The provincial tax falls onto all enterprises employing electricity, with the sole exception of massive energy-intensive establishments exceeding kWh 200,000 consumption per month (around fifty times the typical monthly electricity requirement of a small firm). Provincial authorities can set a rate between a statewide lower limit of €9.30 and an upper limit of €11.40 per 1,000 kWh. The limits have remained unchanged in nominal terms through the past decade. Electricity tax revenues make above $\frac{1}{3}$ of provincial own revenues, the rest of provincial expenditures - mostly in the areas of environmental protection and road maintenance - being funded by motor vehicle registration taxes and state grants (Di Porto and Revelli, 2012; Revelli, 2010).

I use a number of indicators of economic performance. The first is energy consumption at the provincial level, that is available by sector of economic activity on an yearly basis for the entire decade $2000 - 2010$.[16] Energy consumption data come from the nationwide holder of the electricity grid (TERNA, Rete Elettrica Nazionale). Since I do not have micro-level data on energy use by plants, I investigate the effect of the energy tax both on total business energy consumption in a province, and on business use in the service sector, where average firm size is small and energy consumption is moderate. This includes professional, craft, wholesale, retail and catering businesses. I also test the effect of the tax on domestic energy consumption, which should be nil given that domestic consumption is exempt from the tax.

Second, I use a number of variables measured at the regional level and available from ISTAT, National Statistics Institutes, including GDP and employment by sector of economic activity for the period $2000 - 2009$. Moreover, I exploit information from EUROSTAT Statistics on human resources in science and technology (S&T) occupations. Moving to the regional level substantially reduces the number of observations (from over a thousand to less than 200), but allows me to examine a richer set of indicators of real economic activity. In particular, given the lack of territorial capital stock data, the size of human resources in S&T occupations - available by level of skill - can be interpreted (as discussed below) as a proxy for energy-saving capital. Finally, I use provinces' and regions' resident population size and age structure as controls. Summary

[15] Holmes (1998) uses US county manufacturing employment data to test the effect of state policies on the location of business. Devereux, Griffith and Simpson (2007) use plant-level data to study firms' location choices at the level of the UK counties. As argued by Guiso, Sapienza and Zingales (2004) in their analysis of the economic impact of local financial development within an integrated financial market in Italy: "From an economic point of view the natural unit of analysis is the province."

[16] Three regions (two small bilingual regions in the Alps, and the island of Sardinia) and the corresponding seven provinces are excluded from the analysis beacuse of their peculiar institutional status and of substantial changes in their structure of local government during the decade considered here. Further, three provinces involved by boundary changes due to the creation of new local authorities are excluded too. This leaves us with data on 93 provinces.

statistics are reported in table 2.

4.2 Estimation results

Tables 3 and 4 report the energy use estimation results on the panel of provinces. All variables are in logs, and reported standard errors are clustered by region. I control for nationwide influences on economic activity (such as state corporate tax policy, pre-tax energy price movements, and the business cycle) by including year dummies, and for unobserved time-invariant provincial traits by demeaning. Table 3 only includes the provincial and regional tax rates as explanatory variables, while the specifications in table 4 control for resident population size and share of elderly population, as well as for GDP measured at the regional level.[17]

The results reveal virtually no impact of the two tax rates on total or domestic electricity consumption: the latter turns out to be largely driven by the size of resident population (column (4.2)), with an elasticity of 0.6. On the other hand, the regional business income tax rate has a positive and significant effect (an elasticity of about 0.2) on total business electricity consumption and on the part of it that is used in the service sector. The former effect is less precisely estimated, though, when GDP is controlled for in table 4: total business electricity consumption increases with GDP with an elasticity of 0.7, and decreases with the share of elderly population with an elasticity of -0.7. Expectedly, the energy tax turns out to have a significant negative effect in the service sector only, where most small and medium-sized firms that are liable to the payment of the tax are found. The result is robust to the inclusion of population size and composition and GDP as controls. The elasticity of electricity consumption in the service sector to the electricity tax is estimated to be around -0.1.

As a robustness check of the above findings, tables 5 and 6 report the estimation results of specifications where the growth rates of energy use in the various sectors are employed as dependent variables, and are regressed on growth rates of the explanatory variables. Table 6 in particular adds one year lags of the energy use determinants. The overall picture is similar to the one emerging from tables 3 and 4, though the energy tax effect vanishes. However, the impact of the regional business income tax in the service sector remains positive and significant, and GDP and demographic change turn out to be important determinants of total and business electricity consumption growth.

As a further check, table 7 shows the results of estimating a dynamic specification, where a lagged dependent variable is included along with lags of the explanatory variables. I estimate the dynamic panel data model by the conventional Arellano and Bond (1991) generalized method of moments (GMM) that transforms the model in first differences to get rid of the province-specific effects, and uses lags of the dependent variable dated $t-2$ as earlier as instruments for the lagged dependent variable (Arellano and Bond, 1991). I use up

[17] The number of observations falls from 1020 in table 3 to 930 in table 4 because GDP is observed until year 2009 only.

to the fifth lag to build the matrix of instruments. The first and second order serial autocorrelation tests on the first-differenced equation residuals point to the presence of first-order, but not of second-order serial correlation, suggesting that twice lagged values of the dependent variable are valid instruments in the first-differenced equation, while in two of the four equations the Sargan test marginally rejects the hypothesis of instrument orthogonality. Again, the results are generally compatible with the evidence presented above, with GDP playing an important role in explaining energy consumption patterns. The elasticity of energy use with respect to GDP is estimated to be around 0.3, a result that is remarkably robust across the different specifications.[18] As for fiscal policies, the effect of the provincial electricity tax dwindles, while that of the regional business income tax remains fairly strong in the service sector energy use equation.

The above specifications might suffer from an endogeneity problem and thwart our attempt to identify the causal effect of tax policy on variable factor input use if provincial authorities anticipate changes in electricity consumption and manoeuvre their tax rates accordingly. For instance, if local authorities expect energy consumption to decline due, say, to widespread investment in energy-saving technologies or rising energy prices, they might somewhat mechanically be forced to increase the electricity excise tax in order not to see their tax revenues decline. Table 8 presents GMM estimates of a dynamic panel data specification that allows provincial electricity tax rates to be determined endogenously, adding electricity tax rates lagged $t-2$ to $t-5$ to the instrument matrix. The first and second order serial autocorrelation tests as well as the Sargan test now pass in all equations at conventional confidence levels. However, while the effect of the electricity tax on electricity consumption turns out now to be negative and large in the service sector (but not in the other sectors), it is still imprecisely estimated.[19]

Table 9 reports the region-level specifications. Neither tax is estimated to have a significant impact on GDP (column (9.1)), a result in line with Romer and Romer (2010) finding of little macroeconomic impact of deficit-driven tax increases. Leaving aside the issue of endogenous inter-regional migration, regional GDP is estimated to grow with population with an elasticity of about 0.3. In column (9.2), employment in the service sector does indeed rise with GDP and declines when the cost of labor increases due to the mandated tax hike, while the effect of the average provincial energy tax is not significant. Columns (9.3) and (9.4) turn to the type of occupation of human resources. In particular, column (9.3) uses the (log of the) stock of human resources in S&T occupation as dependent variable, independently of workers' education level. Column (9.4) focuses instead on highly skilled human resources (those that have successfully completed education at the third level in an S&T field of study) that are employed in an S&T occupation. This mainly includes professionals and technicians with tertiary education, such as, for instance, IT system

[18] Notwithstanding the long disputed energy-growth conundrum (Ozturk, 2010), this result is in line with the cross-country empirical evidence (Belke, Dobnik and Dreger, 2011).

[19] When also allowing for endogeneity of the regional business income tax rate and using lags as instruments, the results are virtually identical as the ones in table 8.

designers, computer programmers, biologists, engineers and economists. In a way, espousing the view of energy-saving capital as a manifestation of human capital in the form of technical skills needed to optimally design and manage a production process, human resources in S&T occupation might be interpretable as a proxy for the stock of energy-saving capital in the regional economy. The results show that the regional tax strongly and significantly affects both variables, with the elasticity being slightly larger (over 0.3 in absolute value) for highly skilled workers. On the other hand, average energy taxes in the region turn out to have no effect on human resources in S&T, plausibly due to the fact that I cannot distinguish here between human resources that are employed by large, energy-intensive firms that are exempt from the provincial electricity tax and those in small and medium enterprises.

4.3 Spatial spillovers

Spatial differences in factor input prices could in principle foster mobility of business activity across localities, and make economic outcomes and tax bases in a jurisdiction depend on tax policies implemented in other jurisdictions (Brueckner, 2003). Ignoring cross-locality fiscal spillovers when they are actually important might yield biased estimates of the impact of local taxes on economic activity if decentralized tax policy follows a spatial auto-correlation pattern. If economic activity in locality l (X_{lt}) is affected by tax policy in locality j ($\mathbf{z}_{jt}$) due, say, to tax base mobility, and $cov(\mathbf{z}_{lt}, \mathbf{z}_{jt}) \neq 0$, omission of $\mathbf{z}_{jt}$ from the empirical model will cause the estimate of the impact of $\mathbf{z}_{lt}$ on X_{lt} to suffer from a standard omitted variable bias.

In fact, as shown in table 13, the Moran test for spatial dependence reveals some evidence of positive spatial auto-correlation among adjacent provinces' policies in the mid-sample years, while the null hypothesis of random assignment of energy tax rates in space cannot be rejected either in the early sample years, or towards the end of the decade, when most provincial authorities were against the statewide upper tax rate bound.[20] In order to test for the relevance of fiscal spillovers, I allow tax policies in neighboring localities to have an effect on economic performance in a locality. In particular, for each province and year, I take a spatially weighted average of electricity tax rates in the other $L-1$ provinces:

$$\widetilde{\mu}_{lrt} = \sum_{j=1}^{L} \omega_{lj} \mu_{jst} \tag{14}$$

where $\{\omega_{lj}\} \geq 0$ - with $\omega_{lj} = 0$ if $l = j$ - is a set of non-stochastic weights based on provinces' geographic location, and might well equal (or be close to) zero for a non-negligible number of (l, j) pairs (Anselin, 1988). Similarly, for each region $r = 1, ..., R$ and each year, I build a spatially weighted average of

[20] The Moran statistic equals $(\widetilde{X}'\widetilde{X})^{-1}\widetilde{X}'\mathcal{W}\widetilde{X}$, with $\widetilde{X}$ as the demeaned vector of the variable of interest, and $\mathcal{W}$ a square matrix weighting observation pairs (typically in a binary way) based on their vicinity (Anselin, 1988). In fact, the Moran statistic is the OLS estimate from a regression of a first-order spatial lag of X on X.

business income tax rates in the other $R-1$ regions:

$$\widetilde{\tau}_{rt} = \sum_{s=1}^{R} \omega_{rs}\tau_{st} \tag{15}$$

where the ω_{rs} weights play a similar role as ω_{lj}. In fact, $\omega_{lj} = \omega_{rs}$ would imply that all provinces located in a region are exposed to spill-overs of the same intensity from tax policies in nearby regions, irrespective of their own within-region location.

Based on (14) and (15), I experimented with a number of spatial patterns that differ by range and complexity. I report three sets of results in tables 10 to 12 based on fairly standard spatial modelling choices (McMillen, 2010). Table 10 reports the results of a region-level specification that relies on a border-sharing criterion, meaning that $\omega_{rs} = \frac{1}{n_r}$ if regions r and s share a border, with n_r standing for the number of adjacent regions to region r, and $\omega_{rs} = 0$ otherwise. The resulting spatial term in equation (15) is the average business income tax rate in the regions bordering region r.[21] Tables 11 and 12 report the estimation results of province-level spatial specifications for the use of energy. In table 11, I use a border-sharing criterion, where energy use in a province is allowed to be affected by the average energy tax in adjacent provinces, irrespective of whether those provinces belong to the same or different regions. In table 12, I use instead the average value added taxes and average provincial energy taxes in the set of regions bordering the region where a province is located.

The results show no evidence of significant fiscal spillovers in either of those spatial models, suggesting that tax policy changes did not bring about any major shift of production facilities or variable factor input use to low-tax localities, with factor input adjustment mostly taking place within localities. In fact, due to plant relocation costs, shifting real production across localities in response to tax differentials only tends to be a feasible option for multiplant firms operating establishments in different sites (Markusen, 1995), with local business responding to fiscal shocks in the short run chiefly by manoeuvring their flexible factor input mix.

5 Concluding remarks

While the influence of tax policy on investment, employment and output growth has long been studied in theoretical and empirical research, the global recession and financial crisis of 2008–2009 put the search for effective fiscal stimulus policies centre stage in academic as well as political discourses. On the other hand, the disclosure of widespread local public finance distress in multi-tiered government structures seems to call for top-down fiscal consolidation policies that could actually harm economic recovery and endanger the founding principles of fiscal federalism in terms of fiscal autonomy and accountability.

[21] Each region has one to four neighbors. The island of Sicily is assumed to have as sole neighbor the region of Calabria, at the extreme south-west of the peninsula.

Much of the academic and political controversy about the design of tax policy and its expansionary *versus* contractionary effects seems to arise from the fact that "economists have surely not settled on a definitive theoretical model to assess macroeconomic effects of government purchases and taxes" (Barro and Redlick, 2011: p. 67), or, even more importantly, from the dismal admission that applied research on the response of real economic aggregates to changes in government policies is "largely silent concerning whether the output effects operate through incentives and supply behavior or through disposable income and demand stimulus" (Romer and Romer, 2010: p. 799). As a result, most recent empirical works in this area take a fairly pragmatic stance and focus on the policy endogeneity issue, offering ingenious econometric approaches based either on the exploitation of spatial discontinuities at administrative borders, or on deep, narrative accounts of observed discretionary tax changes to tell exogenous from endogenously determined ones.

This paper has put forward a novel, institution-based approach to dealing with policy endogeneity in hierarchical government structures. It relies on state-mandated local tax increases in order to identify the causal effect of factor input taxes on their use. Exploiting the exogenous nature of externally enforced tax increases to deal with inherited budget deficits can complement existing empirical methods, and is potentially applicable to federal structures as the EU.

In particular, I have made use of the tax rate increases that were mandated by the state in the Italian regions with excessive budget deficits around the mid 2000s. The release of sensational data on the debt accumulated over the latest terms of office in a number of regions led the state government in 2006 to mandate increases in regional own business income tax rates in order to have the burden of debt recovery fall onto those regions' taxpayers. I have investigated the impact of regional business income taxes and provincial energy taxes on a number of indicators of local economic activity. The panel data estimation results reveal that mandated regional tax hikes had a significant detrimental impact on employment in the service sector and particularly on the use of human resources in S&T occupations, the latter being interpretable as a proxy for energy-saving capital, and a positive impact on province-level business energy use, lending support to the hypothesis of short run substitution between energy and energy-saving capital. On the other hand, while there is no evidence of major shift of production facilities or variable factor input use to low-tax localities, provincial excise taxes on energy are found to discourage business consumption of energy.

Finally, this paper has not tackled some important related issues. The first concerns how political support for fiscal mandates arises and evolves in federations, along the lines of the political economy analyses of tax and expenditure limitations in Nechyba (1997), Cremer and Palfrey (2000), Vigdor (2004) and Calabrese and Epple (2010). Given the pervasiveness of limits, mandates and other forms of central command on local authorities' policies, the genesis and transformation of those institutional arrangements in times of sovereign debt crisis and fiscal consolidation seem to represent important topics for further research. Second, I have not discussed the relative merits of alternative, non-hierarchical central-local institutional arrangements, particularly the design of US state-like mechanisms that give locally generated debt obligations priority over other expenditures (Cooley and Marimon, 2011). Since unsustainable local fiscal policies turn into local rather than national political problems under such arrangements, it would then be local constituencies' responsibility to mandate fiscal discipline on their own administrators.

References

[1] Anselin, L. (1988) Spatial Econometrics: Methods and Models. Kluwer Academic: Dordrecht.

[2] Arellano, M., Bond, S. (1991) Some tests of specification for panel data; Monte Carlo evidence and an application to employment equations, Review of Economic Studies 58, 277-297.

[3] Atkeson, A., Kehoe, P. (1999) Models of energy use: Putty-putty versus putty-clay, American Economic Review 89, 1028-1043.

[4] Barro, R., Redlick, C. (2011) Macroeconomic effects from government purchases and taxes, Quarterly Journal of Economics 126, 51-102.

[5] Bartik, T. (1985) Business location decisions in the United States: Estimates of the effects of unionization, taxes, and other characteristics of states, Journal of Business & Economic Statistics 3, 14-22.

[6] Belke, A., Dobnik, F., Dreger, C. (2011) Energy consumption and economic growth: New insights into the cointegration relationship, Energy Economics 33, 782–789.

[7] Bird, R. (2003) A new look at local business taxes, Tax Notes International, May 19, 695-711.

[8] Blendon, R., Kim, M., Benson, J. (2001) The public versus the World Health Organization on health system performance, Health Affairs 20, 10-20.

[9] Bordignon, M., Giannini, S., Panteghini, P. (2001) Reforming business taxation: lessons from Italy? International Tax and Public Finance 8, 191-210.

[10] Bordignon, M., Turati, G. (2009) Bailing out expectations and public health expenditure, Journal of Health Economics 28, 305-321.

[11] Bresnahan, T., Brynjolfsson, E., Hitt, L. (2002) Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence, Quarterly Journal of Economics 117, 339-376.

[12] Brueckner, J. (2003) Strategic interaction among governments: An overview of empirical studies, International Regional Science Review 26, 175-188.

[13] Brynjolfsson, E., Hitt, L. (2002) Beyond computation: Information technology, organizational transformation and business performance, Journal of Economic Perspectives 14, 23-48.

[14] Brynjolfsson, E., Hitt, L., Yang, S. (2002) Intangible assets: Computers and organizational capital, Brookings Papers on Economic Activity 2002(1), 137-181.

[15] Brulhart, M., Jametti, M., Schmidheiny, K. (2012) Do agglomeration economies reduce the sensitivity of firm location to tax differentials? Economic Journal (forthcoming).

[16] Calabrese, S., Epple, D. (2010) On the political economy of tax limits. IEB Barcelona, Working Paper No. 14.

[17] Cloyne, J. (2011) What are the effects of tax changes in the United Kingdom? New evidence from a narrative evaluation, CESifo Working Paper.

[18] Cooley, T., Hansen, G., Prescott, E. (1995) Equilibrium business cycles with idle resources and variable capacity utilization, Economic Theory 6, 35-49.

[19] Cooley, T., Marimon, R., (2011) A credible commitment for the Eurozone, VoxEU.org, 20 July.

[20] Cremer, J., Palfrey, T. (2000) Federal mandates by popular demand, Journal of Political Economy 108, 904-927.

[21] Devereux, M.P., Griffith, R., Simpson, H. (2007) Firm location decisions, regional grants and agglomeration externalities, Journal of Public Economics 91, 413-435.

[22] Diaz, A., Puch, L., Guillo, M. (2004) Costly capital reallocation and energy use, Review of Economic Dynamics 7, 494-518.

[23] Di Porto, E., Revelli, F. (2012) Tax limited reaction functions, Journal of Applied Econometrics (forthcoming).

[24] Duranton, J., Gobillon, L., Overman, H. (2011) Assessing the effects of local taxation using microgeographic data, Economic Journal 121, 1017-1046.

[25] European Central Bank (2011) Ensuring fiscal sustainability in the euro area, ECB Monthly Bulletin 04 (April), 61-77.

[26] Ferrario, C., Zanardi, A. (2011) Fiscal decentralization in the Italian NHS: What happens to interregional redistribution? Health Policy 100, 71-80.

[27] Goolsbee, A. (1998) Investment tax incentives, prices, and the supply of capital goods, Quarterly Journal of Economics 113, 121-148.

[28] Guiso, L., Sapienza, P., Zingales, L. (2004) Does local financial development matter? Quarterly Journal of Economics 119, 929-969.

[29] Holmes, T. (1998) The effect of state policies on the location of manufacturing: Evidence from state borders, Journal of Political Economy 106, 667-705.

[30] Keen, M. (2003) Tax reform in Italy, Tax Notes International, February 17, 665-682.

[31] Krusell, P., Ohanian, L., Rios-Rull, J., Violante, G. (2000) Capital-skill complementarity and inequality: A macroeconomic analysis, Econometrica 68, 1029-1053.

[32] Lojsch, D., Rodriguez-Vives, M., Slavik, M. (2011) The size and composition of government debt in the euro area, European Central Bank Occasional Paper Series, No. 132.

[33] Lo Scalzo, A., Donatini, A., Orzella, L., Cicchetti, A., Profili, S., Maresso, A. (2009) Italy: Health system review, Health Systems in Transition 11, 1-216.

[34] Maio, V., Manzoli, L. (2002) The Italian health care system: WHO ranking versus public perception, P&T Pharmacy and Therapeutics 27, 301-308.

[35] Markusen, J. (1995) The boundaries of multinational enterprises and the theory of international trade, Journal of Economic Perspectives 9, 169-189.

[36] McMillen, D. (2010) Issues in spatial data analysis, Journal of Regional Science 50, 119-141.

[37] Ministry of Finance and Public Administration (2011) Spain Stability Programme, 2011-14. Madrid: Ministry of Finance and Public Administration.

[38] Nechyba, T. (1997) Local property and state income taxes: The role of interjurisdictional competition and collusion, Journal of Political Economy 105, 351-384.

[39] Ozturk, I. (2010) A literature survey on energy-growth nexus, Energy Policy 38, 340-349.

[40] Pindyck, R., Rotemberg, J. (1983) Dynamic factor demands and the effects of energy price shocks, American Economic Review 73, 1066-1079.

[41] Rathelot, R., Sillard, P. (2008) The importance of local corporate taxes in business location decisions: Evidence from French micro data, Economic Journal 118, 499-514.

[42] Revelli, F. (2010) Tax mix corners and other kinks, IEB Barcelona, Working Paper No. 50.

[43] Romer, C., Romer, D. (2010) The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks, American Economic Review 100, 763–801.

[44] Tediosi, F., Gabriele, S., Longo, F. (2009) Governing decentralization in health care under tough budget constraint: What can we learn from the Italian experience? Health Policy 90, 303-312.

[45] Vigdor, J. (2004) Other people's taxes: Nonresident voters and statewide limitation of local government, Journal of Law and Economics 47, 453-476.

Appendix

Proof of proposition 1

Totally differentiate the first order conditions (4), divide by $d\tau_{rt}$, and rearrange:

$$\begin{aligned}
\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right]\frac{dk_{lrt}}{d\tau_{rt}}+\left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\frac{dh_{lrt}}{d\tau_{rt}}&=\zeta_{rt}\\
\left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\frac{dk_{lrt}}{d\tau_{rt}}-\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\frac{dh_{lrt}}{d\tau_{rt}}&=\zeta_{rt}
\end{aligned}\tag{16}$$

where:

$$\zeta_{rt}\equiv\frac{d}{d\tau_{rt}}\left(\frac{\iota(1-\pi_t)+\delta}{1-\pi_t-\tau_{rt}}\left[1-\delta_0\frac{\pi_t+\tau_{rt}}{\iota(1-\pi_t)+\delta}\right]\right)=\frac{\iota(1-\pi_t)+(\delta-\delta_0)}{\left(1-\pi_t-\tau_{rt}\right)^2}>0$$

Solving system (16) by Cramer's rule:

$$\begin{aligned}
\frac{dk_{lrt}}{d\tau_{rt}}&=\frac{\begin{vmatrix}\zeta_{rt} & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\\ \zeta_{rt} & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}}{\begin{vmatrix}\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}}\\
&=\zeta_{rt}\frac{-2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}-\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}}{\mathfrak{D}}<0
\end{aligned}\tag{17}$$

$$\begin{aligned}
\frac{dh_{lrt}}{d\tau_{rt}}&=\frac{\begin{vmatrix}\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \zeta_{rt}\\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & \zeta_{rt}\end{vmatrix}}{\begin{vmatrix}\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}}\\
&=\zeta_{rt}\frac{(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta-\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}}{\mathfrak{D}}<0
\end{aligned}\tag{18}$$

The determinant $\mathfrak{D}$ in the denominator is positive due to concavity of the profit function (3). This proves parts (i) and (ii) of the proposition. Using (1), (17), and (18), and the fact that $\theta\alpha_l k_{lrt}^{\theta-1}\eta-\left(v+\mu_{lrt}\right)\gamma h_{lrt}^{-1}=\left(v+\mu_{lrt}\right)\gamma k_{lrt}h_{lrt}^{-2}$

from the first order conditions (4), the effect on the use of energy is:

$$\begin{aligned}\frac{d\varepsilon_{lrt}}{d\tau_{rt}} &= \frac{\gamma}{h_{lrt}}\left(\frac{dk_{lrt}}{d\tau_{rt}}\right) - \gamma\frac{k_{lrt}}{h_{lrt}^2}\left(\frac{dh_{lrt}}{d\tau_{rt}}\right) \\ &= \zeta_{rt}\frac{\gamma^2}{h_{lrt}\mathfrak{D}}\left(-\theta^2\alpha_l k_{lrt}^{\theta-1}\eta\right) < 0\end{aligned} \tag{19}$$

Proof of proposition 2

Totally differentiate the first order conditions (4), divide by $d\mu_{lrt}$, and rearrange:

$$\begin{aligned}\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right]\frac{dk_{lrt}}{d\mu_{lrt}} + \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\frac{dh_{lrt}}{d\mu_{lrt}} &= \frac{\gamma}{h_{lrt}} \\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right]\frac{dk_{lrt}}{d\mu_{lrt}} - \left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\frac{dh_{lrt}}{d\mu_{lrt}} &= -\frac{\gamma k_{lrt}}{h_{lrt}^2}\end{aligned} \tag{20}$$

Solving system (20) by Cramer's rule:

$$\begin{aligned}\frac{dk_{lrt}}{d\mu_{lrt}} &= \frac{\begin{vmatrix} \frac{\gamma}{h_{lrt}} & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] \\ -\frac{\gamma k_{lrt}}{h_{lrt}^2} & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}}{\begin{vmatrix} \left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] \\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}} \\ &= -\frac{\frac{\gamma k_{lrt}}{h_{lrt}^2}\left(\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right)}{\mathfrak{D}} < 0\end{aligned} \tag{21}$$

$$\begin{aligned}\frac{dh_{lrt}}{d\mu_{lrt}} &= \frac{\begin{vmatrix} \left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \frac{\gamma}{h_{lrt}} \\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & -\frac{\gamma k_{lrt}}{h_{lrt}^2}\end{vmatrix}}{\begin{vmatrix} \left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-2}\eta\right] & \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] \\ \left[\gamma\frac{v+\mu_{lrt}}{h_{lrt}^2}\right] & -\left[2\left(v+\mu_{lrt}\right)\frac{\gamma k_{lrt}}{h_{lrt}^3}\right]\end{vmatrix}} \\ &= -\frac{\frac{\gamma}{h_{lrt}^2}\left[(\theta-1)\theta\alpha_l k_{lrt}^{\theta-1}\eta + \gamma\frac{v+\mu_{lrt}}{h_{lrt}}\right]}{\mathfrak{D}} \\ &= -\frac{1}{\mathfrak{D}}\frac{\gamma^2\left(v+\mu_{lrt}\right)}{h_{lrt}^3}\left[(\theta-1)\frac{k_{lrt}}{h_{lrt}} + \theta\right] \\ &\gtreqless 0 \iff \frac{k_{lrt}}{h_{lrt}} \gtreqless \frac{\theta}{1-\theta}\end{aligned} \tag{22}$$

where I have used $\theta\alpha_l k_{lrt}^{\theta-1}\eta = (v+\mu_{lrt})\,\gamma h_{lrt}^{-1}(1+k_{lrt}h_{lrt}^{-1})$ from (4). Finally, the effect of the excise tax on the use of energy is:

$$\begin{aligned}\frac{d\varepsilon_{lrt}}{d\mu_{lrt}} &= \frac{\gamma}{h_{lrt}}\left(\frac{dk_{lrt}}{d\mu_{lrt}}\right) - \gamma\frac{k_{lrt}}{h_{lrt}^2}\left(\frac{dh_{lrt}}{d\mu_{lrt}}\right) \\ &= \frac{\gamma^2}{h_{lrt}^3\mathfrak{D}}(\theta-1)\theta\alpha_l k_{lrt}^{\theta}\eta < 0\end{aligned} \tag{23}$$

Proof of proposition 3

Derive equation (12) with respect to μ_{lrt}:

$$\begin{aligned}&\frac{dE\left[\mathcal{E}_{lrt}\middle|\,\mathbf{z}_{lrt}\right]}{d\mu_{lrt}} \\ =\;& \frac{\overline{m}_l}{\Delta_c}\left\{-\gamma\frac{k_{lrt}}{h_{lrt}^2}\Pr(c_{lrt}<c_{lrt}^*) + \gamma\frac{k_{lrt}}{h_{lrt}}\left[v_{lrt}\frac{\gamma k_{lrt}}{h_{lrt}^2} - u_{rt}\right]\right\}\frac{dh_{lrt}}{d\mu_{lrt}} \\ &+\frac{\overline{m}_l}{\Delta_c}\gamma\frac{k_{lrt}}{h_{lrt}}\left(\frac{d\Pr(c_{lrt}<c_{lrt}^*)}{d\mu_{lrt}}\right)\end{aligned} \tag{24}$$

Using (6), and totally differentiating it to obtain $\frac{dh_{lrt}}{d\mu_{lrt}}$:

$$\frac{dE\left[\mathcal{E}_{lrt}\middle|\,\mathbf{z}_{lrt}\right]}{d\mu_{lrt}} = -\frac{\overline{m}_l}{\Delta_c}\frac{\gamma k_{lrt}}{h_{lrt}^2}\left\{\frac{h_{lrt}}{2v_{lrt}}\Pr(c_{lrt}<c_{lrt}^*) + k_{lrt}\right\} < 0 \tag{25}$$

Next derive equation (12) with respect to τ_{rt}. Using (6), and with $\iota_t = \iota(1-\pi_t) + (\delta-\delta_0)$:

$$\begin{aligned}&\frac{dE\left[\mathcal{E}_{lrt}\middle|\,\mathbf{z}_{lrt}\right]}{d\tau_{rt}} \\ =\;& \frac{\overline{m}_l}{\Delta_c}\left\{-\gamma\frac{k_{lrt}}{h_{lrt}^2}\Pr(c_{lrt}<c_{lrt}^*)\right\}\frac{dh_{lrt}}{d\tau_{rt}} \\ &+\frac{\overline{m}_l}{\Delta_c}\gamma\frac{k_{lrt}}{h_{lrt}}\left(\frac{d\Pr(c_{lrt}<c_{lrt}^*)}{d\tau_{rt}}\right) \\ =\;& \frac{\overline{m}_l}{\Delta_c}\left\{-\gamma\frac{k_{lrt}}{h_{lrt}^2}\Pr(c_{lrt}<c_{lrt}^*)\right\}\left(-\frac{h_{lrt}^3}{2v_{lrt}k_{lrt}}\frac{\iota_t}{(1-\pi_t-\tau_{rt})^2}\right) \\ &-\frac{\overline{m}_l}{\Delta_c}\gamma\frac{k_{lrt}}{h_{lrt}}\left[\frac{\eta\lambda_{rt}}{1-\pi_t-\tau_{rt}} + h_{lrt}\frac{\iota_t}{(1-\pi_t-\tau_{rt})^2}\right] \\ =\;& \frac{\overline{m}_l}{\Delta_c}\frac{\iota_t\frac{h_{lrt}}{2v_{lrt}}\Pr(c_{lrt}<c_{lrt}^*) - \frac{\gamma k_{lrt}}{h_{lrt}}\left(\eta\lambda_{rt}\left(1-\pi_t-\tau_{rt}\right)+\iota_t h_{lrt}\right)}{(1-\pi_t-\tau_{rt})^2} \\ \gtreqless\;& 0 \iff v_{lrt} \lesseqgtr v_{lrt}^* \equiv \frac{\alpha_l k_{lrt}^{\theta}\eta - \eta\lambda_{rt} - h_{lrt}u_{rt} - \underline{c}}{\frac{\gamma k_{lrt}}{h_{lrt}}\left(2\frac{\eta\lambda_{rt}(1-\pi_t-\tau_{rt})+\iota_t h_{lrt}}{\iota_t h_{lrt}} + 1\right)}\end{aligned} \tag{26}$$

Table 1 Mandated regional business income tax rates (%)

region	2005	2006	2007	2008	2009	2010
Abruzzo	4.25	4.25	5.25	4.82	4.82	4.82
Calabria	4.25	4.25	4.25	3.90	4.82	4.97
Campania	4.25	4.55	5.25	4.82	4.97	4.97
Lazio	4.25	4.25	5.25	4.82	4.82	4.97
Liguria	4.25	4.25	5.25	3.90	3.90	3.90
Molise	4.25	4.25	5.25	4.82	4.82	4.97
Puglia	4.25	4.25	4.25	4.82	4.82	4.82
Sicilia	4.25	4.25	5.25	4.82	4.82	4.82
baseline rate	4.25	4.25	4.25	3.90	3.90	3.90

Table 2 Descriptive statistics

	mean	s.d.	min	max	source
provinces					
electricity use (MWh)					TERNA Rete Elettrica
- total	2,904.8	3,035.3	323.8	21,976.8	
- domestic	646.4	774.8	75.9	5,687.4	
- business	2,258.4	2,377.8	171.5	16,959.5	
- services	583.7	928.7	38.2	7848.5	
electricity rate (€/MWh)	10.5	0.9	9.3	11.4	Italian Government
population (,000)	583.1	645.2	88.7	4194.0	ISTAT
elderly population (%)	20.7	2.9	12.3	27.9	ISTAT
regions					
GDP (€ billion)	69.3	61.2	0.5	268.6	ISTAT
population (,000)	3,282.1	2,350.3	320.0	9,826.1	ISTAT
elderly population (%)	20.7	2.6	15.8	26.7	ISTAT
tertiary employment (,000)	810.4	618.5	63.6	2728.8	EUROSTAT
human resources in S&T	370.3	311.1	27.1	1491.0	EUROSTAT
skilled human res. in S&T	143.2	115.8	10.0	566.1	EUROSTAT
business income tax rate	4.33	0.3	3.9	5.25	Italian Government

Table 3 Province-level electricity use

	Electricity use			
	total	domestic	business	services
	(3.1)	(3.2)	(3.3)	(3.4)
τ_{rt}	0.116	-0.007	0.182**	0.178**
	(0.071)	(0.043)	(0.085)	(0.069)
μ_{lrt}	0.015	0.010	0.008	-0.113**
	(0.055)	(0.024)	(0.067)	(0.051)
obs.	1020	1020	1020	1020

Notes: all variables in logs; year effects and locality fixed effects included; standard errors clustered by region in brackets below the coefficients; ***,** ,*: p-value $< 0.01, 0.05, 0.10$.

Table 4 Province-level electricity use (constant output)

	Electricity use			
	total	domestic	business	services
	(4.1)	(4.2)	(4.3)	(4.4)
τ_{rt}	0.153*	0.042	0.200*	0.185***
	(0.084)	(0.041)	(0.106)	(0.066)
μ_{lrt}	0.021	0.031	0.007	-0.106**
	(0.053)	(0.019)	(0.069)	(0.045)
population	0.475	0.601***	0.348	-0.219
	(0.425)	(0.185)	(0.540)	(0.359)
elderly share	-0.518**	0.171**	-0.657**	-0.159
	(0.322)	(0.071)	(0.247)	(0.250)
GDP	0.511	0.045	0.689*	-0.322
	(0.325)	(0.130)	(0.403)	(0.218)
obs.	930	930	930	930

Notes: see table 3.

Table 5 Province-level electricity use growth

	Electricity use			
	total	domestic	business	services
	(5.1)	(5.2)	(5.3)	(5.4)
τ_{rt}	0.209	-0.024	0.031	0.059**
	(0.031)	(0.024)	(0.037)	(0.024)
μ_{lrt}	0.006	0.034*	-0.006	-0.001
	(0.024)	(0.019)	(0.034)	(0.019)
population	0.181	0.256	0.082	-0.102
	(0.314)	(0.289)	(0.445)	(0.229)
elderly share	-0.517***	0.211	-0.666***	-0.108
	(0.140)	(0.135)	(0.202)	(0.196)
GDP	0.306***	-0.071	0.377***	-0.193
	(0.111)	(0.058)	(0.144)	(0.137)
obs.	837	837	837	837

Notes: all variables in log(difference); one cross-section is lost in building growth rates; year effects included; standard errors clustered by region in brackets below the coefficients; ***,**,*: p-value $<$ 0.01, 0.05, 0.10.

Table 6 Province-level electricity use growth (lagged controls)

	Electricity use			
	total	domestic	business	services
	(6.1)	(6.2)	(6.3)	(6.4)
τ_{rt}	0.032	-0.021	0.047	0.073***
	(0.031)	(0.026)	(0.037)	(0.025)
τ_{rt-1}	-0.008	-0.007	-0.005	0.040
	(0.037)	(0.025)	(0.049)	(0.041)
μ_{lrt}	-0.006	0.042*	-0.028	0.014
	(0.031)	(0.023)	(0.043)	(0.029)
μ_{lrt-1}	-0.015	-0.013	-0.017	-0.008
	(0.029)	(0.023)	(0.039)	(0.027)
population	0.115	0.065	0.081	-0.108
	(0.295)	(0.407)	(0.400)	(0.319)
population_{t-1}	0.137	0.213	0.096	0.012
	(0.304)	(0.244)	(0.350)	(0.192)
elderly share	-0.412	0.481*	-0.719**	0.035
	(0.292)	(0.276)	(0.371)	(0.327)
$\text{elderly share}_{t-1}$	-0.184	-0.268	-0.019	-0.217
	(0.332)	(0.261)	(0.413)	(0.375)
GDP	0.330**	-0.024	0.363**	-0.210
	(0.136)	(0.079)	(0.166)	(0.145)
GDP_{t-1}	0.235*	0.145	0.315*	0.190
	(0.136)	(0.076)	(0.167)	(0.210)
obs.	744	744	744	744

Notes: see table 5.

Table 7 Dynamic province-level electricity use

	Electricity use			
	total	domestic	business	services
	(7.1)	(7.2)	(7.3)	(7.4)
$\mathcal{E}_{lrt-1}$	0.750***	0.026	0.836***	0.458***
	(0.179)	(0.061)	(0.127)	(0.115)
τ_{rt}	0.018	-0.034	0.016	0.073***
	(0.033)	(0.030)	(0.044)	(0.028)
τ_{rt-1}	-0.005	-0.017	-0.025	-0.007
	(0.042)	(0.019)	(0.048)	(0.037)
μ_{lrt}	0.001	0.040	-0.020	0.017
	(0.032)	(0.021)	(0.044)	(0.030)
μ_{lrt-1}	-0.016	-0.014	-0.014	-0.022
	(0.028)	(0.021)	(0.038)	(0.036)
population	0.008	-0.001	0.251	-0.080
	(0.303)	(0.299)	(0.451)	(0.364)
population_{t-1}	0.129	0.281	-0.104	-0.164
	(0.341)	(0.202)	(0.460)	(0.340)
elderly share	0.050	0.477*	-0.262	-0.248
	(0.309)	(0.259)	(0.412)	(0.410)
$\text{elderly share}_{t-1}$	-0.249	-0.329	-0.001	-0.144
	(0.375)	(0.232)	(0.482)	(0.361)
GDP	0.313***	-0.048	0.321*	-0.211
	(0.130)	(0.083)	(0.175)	(0.146)
GDP_{t-1}	0.118	0.230*	0.060	0.308
	(0.148)	(0.123)	(0.203)	(0.205)
AR(1) test (p value)	-3.27 (0.00)	-1.60 (0.10)	-4.27 (0.00)	-4.21 (0.00)
AR(2) test (p value)	-0.38 (0.70)	0.10 (0.92)	-0.11 (0.92)	-0.80 (0.43)
Sargan test (p value)	37.12 (0.14)	50.44 (0.01)	30.57 (0.39)	46.39 (0.02)
obs.	744	744	744	744

Notes: Arellano and Bond (1991) generalized method of moments estimator; first step results; robust standard errors in brackets; instruments used until lag t-5; AR(1) and AR(2) are tests for first and second order serial correlation respectively, and are distributed as standard normal; the Sargan test is distributed as χ^2 with 29 degrees of freedom (number of overidentifying restrictions); ***,** ,*: p-value $<$ 0.01, 0.05, 0.10.

Table 8 Dynamic province-level electricity use (endogenous electricity tax)

	Electricity use			
	total	domestic	business	services
	(8.1)	(8.2)	(8.3)	(8.4)
$\mathcal{E}_{lrt-1}$	0.717***	0.028	0.811***	0.356***
	(0.143)	(0.067)	(0.104)	(0.109)
τ_{rt}	0.018	-0.035	0.021	0.078***
	(0.030)	(0.031)	(0.039)	(0.032)
τ_{rt-1}	-0.006	-0.016	-0.013	0.009
	(0.042)	(0.020)	(0.049)	(0.037)
μ_{lrt}	0.016	-0.034	0.030	-0.250
	(0.084)	(0.070)	(0.115)	(0.156)
μ_{lrt-1}	0.038	0.016	0.057	0.111
	(0.086)	(0.054)	(0.105)	(0.144)
population	-0.026	-0.014	0.190	-0.371
	(0.268)	(0.294)	(0.434)	(0.378)
population$_{t-1}$	0.208	0.271	0.024	-0.011
	(0.303)	(0.206)	(0.429)	(0.361)
elderly share	0.013	0.471*	-0.289	-0.285
	(0.308)	(0.259)	(0.412)	(0.425)
elderly share$_{t-1}$	-0.232	-0.324	0.015	-0.090
	(0.378)	(0.239)	(0.481)	(0.355)
GDP	0.342***	-0.061	0.351**	-0.228
	(0.132)	(0.091)	(0.179)	(0.159)
GDP$_{t-1}$	0.143	0.212*	0.111	0.321
	(0.139)	(0.126)	(0.189)	(0.221)
AR(1) test (p value)	-3.65 (0.00)	-1.68 (0.09)	-4.58 (0.00)	-3.35 (0.00)
AR(2) test (p value)	-0.41 (0.68)	0.21 (0.83)	-0.18 (0.86)	-1.38 (0.17)
Sargan test (p value)	64.77 (0.11)	69.26 (0.06)	57.34 (0.28)	54.14 (0.39)
obs.	744	744	744	744

Notes: Arellano and Bond (1991) generalized method of moments estimator; first step results; robust standard errors in brackets; instruments used until lag t-5; AR(1) and AR(2) are tests for first and second order serial correlation respectively, and are distributed as standard normal; the Sargan test is distributed as χ^2 with 52 degrees of freedom (number of overidentifying restrictions); ***,**,*: p-value $<$ 0.01, 0.05, 0.10.

Table 9 Region-level economic indicators

	GDP	tertiary employment	human resources in S&T	
			total	highly skilled
	(9.1)	(9.2)	(9.3)	(9.4)
τ_{rt}	0.021	-0.104***	-0.276***	-0.316***
	(0.020)	(0.037)	(0.077)	(0.117)
μ_{lrt}	-0.020	0.002	0.163	0.011
	(0.040)	(0.072)	(0.149)	(0.228)
population	0.317***	0.103	0.673**	-0.310
	(0.087)	(0.165)	(0.341)	(0.521)
elderly share	-0.143	-0.158	-0.503	-1.216**
	(0.095)	(0.174)	(0.359)	(0.549)
GDP		0.349**	0.212	-0.059
		(0.153)	(0.316)	(0.483)
obs.	170	170	170	170

Notes: all variables in logs; year effects and locality fixed effects included; ***,** ,*: p-value < 0.01, 0.05, 0.10.

Table 10 Spatial spillovers: regions (border sharing)

	GDP	tertiary employment	human resources in S&T	
			total	highly skilled
	(10.1)	(10.2)	(10.3)	(10.4)
τ_{rt}	0.021	-0.126***	-0.236***	-0.335***
	(0.022)	(0.040)	(0.083)	(0.127)
μ_{lrt}	-0.020	0.022	0.126	0.028
	(0.041)	(0.073)	(0.152)	(0.233)
$\widetilde{\tau}_{rt}$	0.001	0.089	-0.166	0.080
	(0.035)	(0.063)	(0.130)	(0.200)
population	0.318***	0.176	0.538	-0.244
	(0.092)	(0.172)	(0.356)	(0.548)
elderly share	-0.143	-0.118	-0.577	-1.180**
	(0.097)	(0.175)	(0.363)	(0.558)
GDP		0.348**	0.213	-0.059
		(0.152)	(0.316)	(0.484)
obs.	170	170	170	170

Notes: see table 8.

Table 11 Spatial spillovers: provinces (border-sharing)

	Electricity use		
	total	business	services
	(11.1)	(11.2)	(11.3)
τ_{rt}	0.156*	0.205*	0.180***
	(0.084)	(0.105)	(0.065)
μ_{lrt}	0.118	0.003	-0.102**
	(0.052)	(0.068)	(0.048)
$\widetilde{\mu}_{lrt}$	0.066	0.091	-0.085
	(0.106)	(0.134)	(0.112)
population	0.486	0.364	-0.234
	(0.439)	(0.558)	(0.349)
elderly share	-0.521**	-0.662**	-0.155
	(0.196)	(0.248)	(0.257)
GDP	0.498	0.670*	-0.305
	(0.314)	(0.390)	(0.222)
obs.	930	930	930

Notes: see table 3.

Table 12 Spatial spillovers: provinces (cross-region)

	Electricity use		
	total	business	services
	(12.1)	(12.2)	(12.3)
τ_{rt}	0.135*	0.193**	0.138**
	(0.067)	(0.084)	(0.056)
μ_{lrt}	0.040	0.031	-0.089*
	(0.044)	(0.057)	(0.048)
$\widetilde{\tau}_{rt}$	0.151	0.155	0.212
	(0.096)	(0.125)	(0.127)
$\widetilde{\mu}_{lrt}$	0.195	0.291	0.093
	(0.298)	(0.404)	(0.286)
population	0.541	0.425	-0.146
	(0.392)	(0.494)	(0.362)
elderly share	-0.512**	-0.658**	-0.134
	(0.185)	(0.238)	(0.253)
GDP	0.446	0.402	-0.394
	(0.323)	(0.390)	(0.208)
obs.	930	930	930

Notes: see table 3.

Table 13 Moran test on provincial electricity tax rates

	Moran test (p value)
2000	0.03 (0.54)
2001	0.06 (0.31)
2002	0.09 (0.14)
2003	0.12 (0.07)
2004	0.10 (0.15)
2005	0.17 (0.02)
2006	0.18 (0.01)
2007	0.13 (0.05)
2008	0.05 (0.38)
2009	0.05 (0.38)

Notes: 93 provincial electricity tax rates in each cross-section; the Moran statistic is asymptotically normally distributed.