*** THE APPENDICES ARE NOT FOR PUBLICATION ***

Appendix A: The Tax Reaction Function: An Explicit Derivation

This appendix contains a detailed development of our model of strategic competition and extracts implications for the tax reaction function – the equilibrium response of tax policy in a home (in-state) jurisdiction to tax policy in a foreign (out-of-state) jurisdiction. It is complementary to the discussion in Section II and Figure 5. We show that the slope of the reaction function can be positive ("racing to the bottom") or negative ("riding on a seesaw") and that the sign of this slope depends on the sign of one key parameter – the income elasticity of private goods relative to public goods. The sign of this elasticity is related to whether private goods as a whole are a necessary or luxury goods, a condition closely related to the validity of Wagner's Law.[1] The model developed in this section is useful for identifying the determinants of the slope of the reaction function, suggesting hypotheses, and interpreting the empirical results.

A. A Model Of Tax Competition

Our model of tax competition is based on six relations that describe the constraints faced by a government choosing business capital tax policy to maximize the utility of the representative domestic household. First, production in the home state is determined by a Cobb-Douglas function that depends on a mobile capital stock and a fixed factor of production, such as land or infrastructure (the Cobb-Douglas assumption is adopted for analytic convenience). The capital stock available for home production (K) is the sum of the capital stocks owned by home residents (k) and, given the mobility of capital, the capital stock owned by foreign residents but located in the home state (k^f).[2] We write the production function ($F[K]$) in the following intensive form relative to the fixed factor of production (note that brackets are used in this paper to identify arguments in functional relations),

$$y = F[K], \tag{A-1}$$

$$K \equiv k + k^f,$$

$$F'[K] > 0, \; F''[K] < 0.$$

[1] Wagner's Law states that the share of government spending (as a percentage of GDP) increases with aggregate income. It is named after the 19th century German economist, Adolph Wagner.

[2] If the state is a net capital exporter, $k^f < 0$. Without loss in generality, we analyze a capital importing state.

Second, as a result of capital mobility, the capital stock in a given state is sensitive to capital income tax rates prevailing in home and foreign states. Consequently, the capital stock in the home state depends negatively on the home capital tax rate (τ) and positively on the foreign capital tax rate (τ^f), as well as on a set of controls reflecting home and foreign demographic and economic variables (x_k and x_k^f , respectively),

$$k^f = K[\tau : \tau^f, x_k, x_k^f], \qquad \text{(A-2)}$$

$$K_\tau[.] < 0, \;\; K_{\tau^f}[.] > 0.$$

This capital mobility function allows economic and demographic variables to affect home capital demand insofar as they impact production possibilities and the marginal product of capital. It proves convenient to assume that the derivatives with respect to the home and foreign capital tax rates are equal and opposite in sign ($K_\tau[.] = -K_{\tau^f}[.]$), though the qualitative results do not require this assumption.[3]

Equations (A-1) and (A-2) can be combined to generate a relation between production and the home and foreign tax rates,

$$y = F[K] = F\left[K[\tau : \tau^f, x_k, x_k^f]\right] = G\left[\tau : \tau^f, x_k, x_k^f\right], \qquad \text{(A-3)}$$

$$G_\tau[.] < 0, \;\; G_{\tau^f}[.] > 0.$$

The derivative, $G_{\tau^f}[.] > 0$, represents the incremental home production from a tax-induced flow of capital from the foreign state to the home state.

Third, we link net income to expenditures by means of GDP accounting relations. Net income available for domestic expenditures is measured by gross income (production) less the return on capital assets (r^f) owned by foreign residents but located in the home state. Net income is set equal to domestic expenditures, defined as the sum of public goods (g) and private goods (c),

$$y - r^f = g + c. \qquad \text{(A-4)}$$

Fourth, the government budget constraint (stated per unit of the fixed factor) equates public goods expenditure to two sources of tax revenue. For the purposes of this study, the most

[3] While equation (A-2) and its partial derivatives are consistent with the implications from the standard constraint equating net-of-tax returns across jurisdictions, our formulation allows for the possibility that, owing to a variety of frictions (discussed in the literature on the Lucas Paradox (Lucas, *American Economic* Review, 1980), the net-of-tax returns on capital may differ. See Appendix B.1 for analytic details about the capital mobility function.

important tax is an origin-based tax on capital income. This tax is defined as the product of the capital income tax rate (τ) and capital income, the latter defined as the marginal product of capital ($F'[K]$) multiplied by the capital stock located in the home state. The second source of revenue is a sales tax defined as the product of the sales tax rate (s) and income. This tax rate will be held constant in this analysis. The government budget constraint becomes,

$$g \;=\; \tau\; F'[K]\, K + s\, y \;=\; \tau\, \pi\, y + s\, y \;=\; (\tau\, \pi + s)\, y.^{4} \tag{A-5}$$

Fifth, capital imported from abroad is paid a return equal to the marginal product of capital multiplied by the amount of foreign capital located in the home state. As a result of the Cobb-Douglas production function, the return on imported capital is a fixed share (π^f) of output,

$$r^f \;=\; F'[K]\, k^f \;=\; \pi^f\, y, \tag{A-6}$$

$$\pi^f < \pi.$$

Equations (A-4), (A-5), and (A-6) can be combined to generate a relation between the mix of public and private goods ($g/c \;\equiv\; \zeta$) and the capital tax rate. We multiply and divide the two terms on the right-side of equation (A-4) by g, use equations (A-5) and (A-6) to eliminate g and r^f, respectively, and rearrange the resulting equation to obtain the following equation,

$$\zeta \;\equiv\; g/c \;=\; \frac{(\tau\pi+s)}{(1-\pi^f)-(\tau\pi+s)} \;\equiv\; S[\tau], \tag{A-7}$$

$$S_\tau[.] > 0.$$

This condition shows that an increase in the share of output devoted to public goods requires an increase in the capital tax rate. Equation (A-7) is the supply curve presented in Figure 1 ζ to τ.

The sixth and final equation is the utility function that represents preferences for public and private goods. This function and its implications for ζ were discussed in Section II.B, and is repeated here for convenience,

[4] A wage tax at rate τ_{wage} could enter the model by adding ($\tau_{wage}\,(1-\pi)\, y$) to the right side of equation (A-5).

$$\zeta \;\equiv\; g/c \;=\; \xi\, p\left(y(1-\pi^f)\right)^{\eta_{\zeta,y}} \;=\; \xi\, p\left(G\left[\tau:\tau^f, x_k, x_k^f\right](1-\pi^f)\right)^{\eta_{\zeta,y}} \;=\; D\left[\tau:\tau^f, \eta_{\zeta,y}\right], \quad \text{(A-8a)}$$

$$\xi \equiv \left(\xi_g\theta_g / \xi_c\theta_c\right) > 0, \quad \text{(A-8b)}$$

$$p \equiv \left(p_c^{(\theta_c+1)} / p_g^{(\theta_g+1)}\right) > 0, \quad \text{(A-8c)}$$

$$\eta_{\zeta,y} \equiv \theta_g - \theta_c >=< 0. \quad \text{(A-8d)}$$

where, in equation (A-8a), we have substituted for y with equation (A-3). Equation (A-8a) is the demand curve presented in Figure 1 relating ζ to τ, τ^f, and $\eta_{\zeta,y}$.

The above model serves as a vehicle for studying the properties of the tax reaction function. The model is summarized by equations (A-3), (A-7), and (A-8). Substituting the first two equations into the third equation, we determine the optimal capital tax rate, τ^*, and its relation to the foreign capital tax rate,

$$g/c \;=\; \zeta[y(1-\pi^f) \;:\; x_\zeta], \quad \text{(A-9)}$$

$$0 \;=\; \zeta\left[G[\tau^*:\tau^f, x_k, x_k^f]\,(1-\pi^f) \;:\; x_\zeta\right] \;-\; S[\tau],$$

$$0 \;=\; \Phi[\tau^*:\tau^f, x].$$

$$x \equiv \{x_k, x_k^f, x_\zeta, \pi^f, \pi, s\}$$

Appendix B.2 verifies the existence of τ^*.

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Appendix B: Additional Analytic Results For The Strategic Tax Competition Model

Appendix B.1; Properties Of The Capital Mobility Function

This appendix provides some analytic details concerning the properties of the capital mobility function (equation (A-2)) used in this paper. This function allows for the possibility that, owing to a variety of frictions, the net-of-tax returns on capital may differ across jurisdictions. This appendix demonstrates that the capital mobility function and its partial derivatives are consistent with the implications from the standard constraint equating net-of-tax returns across jurisdictions.

Equation (A-2) is reproduced here as follows,

$$k^f = K[\tau : \tau^f, x_k, x_k^f], \qquad \text{(B.1-1)}$$

$$K_\tau[.] < 0, \;\; K_{\tau^f}[.] > 0.$$

where k^f is the capital stock owned by foreign residents but located in the home state. Without loss of generality, we assume that the home state is a capital importer.

The purpose of this exercise is to derive the properties of this function from a generalized equation relating net-of-tax returns in the home and foreign jurisdictions, which is written as follows,

$$(1-\tau)\, F'[K] + \Delta = (1-\tau^f)\, \Im'[K^f], \qquad \text{(B.1-2)}$$

where Δ is a wedge that represents a variety of frictions preventing equalization of net-of-tax returns across jurisdictions, $F'[K]$ and $\Im'[K^f]$ are the marginal products of capital for the home and foreign jurisdictions, respectively. The production functions for both jurisdictions are subject to the Inada conditions (which guarantee that equation (B.1-2) will hold for some capital allocation). We assume that there is a fixed amount of capital ($\bar{K}$) that is allocated between the home and foreign jurisdictions,

$$K = \bar{K} + k^f, \qquad \text{(B.1-3a)}$$

$$K^f = \bar{K}^f - k^f\;, \qquad \text{(B.1-3b)}$$

where $\bar{K}$ and $\bar{K}^f$ are the initial amounts of capital in the home and foreign states, respectively. Substituting equation (B.1-3) into (B.1-2), differentiating the resulting expression by k^f, τ, and τ^f, noting that $dK = dk^f$, and rearranging, we obtain the following derivatives,

$$K_{\tau}[.] \equiv \frac{dK}{d\tau} = \frac{F'[.]}{(1-\tau)\ F''[.] + (1-\tau^{f})\ \Im''[.]} < 0\,, \tag{B.1-4a}$$

$$K_{\tau^{f}}[.] \equiv \frac{dK}{d\tau^{f}} = \frac{-\Im'[.]}{(1-\tau)\ F''[.] + (1-\tau^{f})\ \Im''[.]} > 0\,, \tag{B.1-4b}$$

where we have assumed that the production functions exhibit diminishing marginal products ($F''[.] < 0\,, \Im''[.] < 0$). If the production functions are identical across jurisdictions, then $K_{\tau}[.] = -K_{\tau^{f}}[.]$.

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Appendix B.2: The Existence Of An Equilibrium Tax Rate And Its Relation To The Pre-Tax Capital Income Share

This appendix provides some analytic details concerning the existence of an equilibrium tax rate (τ^*) in the indirect utility model and its relation to the pre-tax capital income share and the rate of sales taxation. We analyze a symmetric equilibrium between home and foreign jurisdictions. We begin with the three relations that summarize the content of the theoretical model presented in Section II.A,

$$y = F[K] = F\left[K[\tau : \tau^f, x_k, x_k^f]\right] = G\left[\tau : \tau^f, x_k, x_k^f\right], \tag{B.2-1}$$

$$G_\tau[.] < 0, \quad G_{\tau^f}[.] > 0.$$

$$\zeta \equiv g/c = \frac{(\tau\pi + s)}{(1-\pi^f) - (\tau\pi + s)} \equiv S[\tau], \tag{B.2-2}$$

$$S_\tau[.] > 0.$$

$$\zeta \equiv g/c = \xi\, p\left(y(1-\pi^f)\right)^{\eta_{\zeta,y}} = \zeta\left[y : \xi, p, \pi^f\right] = D[\tau], \tag{B.2-3a}$$

$$\xi \equiv \left(\xi_g\theta_g / \xi_c\theta_c\right) > 0, \tag{B.2-3b}$$

$$p \equiv \left(p_c^{(\theta_c+1)} / p_g^{(\theta_g+1)}\right) > 0, \tag{B.2-3c}$$

$$\eta_{\zeta,y} \equiv \theta_g - \theta_c >=< 0. \tag{B.2-3d}$$

where equation (B.2-1) is equation (A-3) representing the production function and the mobile capital stock, equation (B.2-2) is equation (A-7) representing the aggregate and government budget constraints, and equation (B.2-3) is equation (A-9) representing optimized choices of public and private goods.

Under the symmetry assumption, no capital flows between jurisdictions because the tax rates are equal. Thus, equation (B.2-1) implies that the level of output in each country is constant, $y = \bar{y}$. Substituting this constant into equation (B.2-3) and eliminating ζ with equation (B.2-2), we obtain the following solution for τ^*

$$\frac{\left(\tau^{*}\pi+s\right)}{\left(1-\pi^{f}\right)-\left(\tau^{*}\pi+s\right)} = \zeta\left[\bar{y} : \xi,\ p,\ \pi^{f}\right],$$

$$\rightarrow \tag{B.2-4}$$

$$\tau^{*} = \frac{\zeta(1-\pi^{f})-s(1+\zeta)}{\pi(1+\zeta)},$$

Since representative estimates of ζ, s, and π are 0.270, 0.025, and 0.33, respectively, $\tau^{*} > 0$ is ensured because the maximum value of π^{f} is π (the capital income share).

Moreover, equation (B.2-4) establishes that there is a negative relation between τ^{*} and the pre-tax capital income share (π), as well as the rate of sales taxation (s).

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Appendix B.3: Comparing the CES Direct and Addilog Indirect Utility Functions

The addilog indirect utility function that is the basis for our theoretical model is used less frequently than a CES direct utility function. (Note that a Cobb-Douglas direct utility function is a special case of the CES.) This appendix compares the implications of both utility functions for the relative public goods ratio, ζ, and shows that the CES direct utility function is less general than the addilog indirect utility function.

The CES direct utility function is written as follows,

$$U[c,g] = \left\{ (\kappa\, g)^{-\rho} + ((1-\kappa)\, c)^{-\rho} \right\}^{-(1/\rho)}, \tag{B.3-1a}$$

$$\rho \equiv (1-\sigma)/\sigma \tag{B.3-1b}$$

where κ is the CES distribution parameter, ρ the substitution parameter, and σ the elasticity of substitution between g and c. The addilog indirect utility function was presented in Section II, and it is reproduced here,

$$V[y] = \xi_g \left(y/p_g \right)^{\theta_g} + \xi_c \left(y/p_c \right)^{\theta_c}. \tag{B.3-2}$$

where $\theta_c, \theta_g, \xi_c$, and ξ_g are positive parameters representing preferences. (For notational simplicity and without loss in generality, we have set $\pi^f = 0$.)

Each utility function generates demand functions for c and g based on optimizing behavior subject to the following budget constraint,

$$y = p_g\, g + p_c\, c, \tag{B.3-3}$$

where p_g and p_c are the prices for g and c, respectively. The demand functions for g and c following from the CES direct utility function are as follows,

$$g = \frac{\kappa^{\sigma}\, p_g^{(1-\sigma)}}{\kappa^{\sigma}\, p_g^{(1-\sigma)} + (1-\kappa)^{\sigma}\, p_c^{(1-\sigma)}} * \frac{y}{p_g}, \tag{B.3-4a}$$

$$c = \frac{(1-\kappa)^{\sigma}\, p_c^{(1-\sigma)}}{\kappa^{\sigma}\, p_g^{(1-\sigma)} + (1-\kappa)^{\sigma}\, p_c^{(1-\sigma)}} * \frac{y}{p_c}, \tag{B.3-4b}$$

These two demand functions imply the following relation for the relative demand for public goods, $\zeta \equiv g/c$,

$$\zeta^{CES} = \left\{\frac{\kappa}{(1-\kappa)}\right\}^{\sigma} \left\{\frac{p_c}{p_g}\right\}^{\sigma}. \tag{B.3-5}$$

As discussed in Section II, a key property of the addilog indirect utility function is that the "ratios between any two expenditures have a constant elasticity with respect to total expenditure" (Houthakker, 1960, p. 253). Relying on Roy's identity to generate the demand functions for c and g, we obtain after some additional manipulation the following equation for the relative demand for public goods (Houthakker, 1960, equation (30)),

$$\zeta^{Addi\log} = \xi \; p \; y^{\eta_{\zeta,y}}, \tag{B.3-6a}$$

$$\xi \equiv \left(\xi_g \theta_g / \xi_c \theta_c\right) > 0, \tag{B.3-6b}$$

$$p \equiv \left(p_c^{(\theta_c+1)} / p_g^{(\theta_g+1)}\right) > 0, \tag{B.3-6c}$$

$$\eta_{\zeta,y} \equiv \theta_g - \theta_c >=< 0. \tag{B.3-6d}$$

A comparison of equations (B.3-5) and (B.3-6) reveals that the addilog indirect utility function yields a more general model of the determinants of the relative demand for public goods. The following restrictions on equation (B.3-6) yield equation (B.3-5) for any values of σ and κ,

$$\theta_g = \theta_c = \sigma - 1, \tag{B.3-7a}$$

$$\xi \equiv \xi_g / \xi_c = \left\{\kappa / (1-\kappa)\right\}^{\sigma}. \tag{B.3-7b}$$

Apart from these restrictions, the addilog model generates a model that is more general and, most importantly for the study of tax competition, allows for income to have a direct impact on the relative demand for public goods.

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Appendix B.4: Tax Competition In A Direct Utility Model

This appendix analyzes the tax competition model developed in Section II with the indirect utility function (equation (8)) replaced by the following direct utility function defined in terms of c and g,

$$U\left[g,c\right] \;=\; \Upsilon\, c^{-\kappa}\, g^{\tilde{\psi}} . \tag{B.4-1}$$

It proves convenient to rewrite equation (B.4-1) in terms of the private/public goods mix variable,

$$U\left[\zeta,c\right] \;=\; \Upsilon\, \zeta^{\kappa}\, g^{\psi} \qquad\qquad \psi \equiv \tilde{\psi} - \kappa . \tag{B.4-2}$$

The optimization problem facing policymakers is to choose τ in order to maximize equation (B.4-2) constrained by equations (A-3), (A-5), and (A-7) reproduced here in abbreviated form for convenience,

$$y \;=\; F[K] \;=\; F\Big[K[\tau:\tau^{f},x_{k},x_{k}^{f}]\Big] \;=\; G\Big[\tau:\tau^{f},x_{k},x_{k}^{f}\Big] , \tag{B.4-3}$$

$$G_{\tau}[.]<0,\;\; G_{\tau^{f}}[.]>0.$$

$$g \;=\; \tau\;\, F'[K]\; K + s\, y \;=\; \tau\, \pi\; y + s\, y \;=\; \left(\tau\, \pi \,+\, s\right) y . \tag{B.4-4}$$

$$\zeta \;\equiv\; g\,/\,c \;=\; \frac{\left(\tau\pi+s\right)}{\left(1-\pi^{f}\right)-\left(\tau\pi+s\right)} \;\equiv\; S[\tau] , \tag{B.4-5}$$

$$S_{\tau}[.]>0 .$$

To simplify the analysis, we have assumed that capital income taxation is the only sources of revenue in equation (B.4-4) (i.e., setting s = 0 in equation (A-5)). Substituting equation (B.4-3) into equation (B.4-4) to eliminate y, and restating ζ and c in equation (B.4-2) in terms of τ with equation (B.4-5) and the modified (B.4-4), respectively, the optimization problem can stated solely in terms of τ,

$$U\left[\tau\right] \;=\; \Upsilon\, \left\{S\left[\tau\right]\right\}^{\kappa}\, \left\{\tau\, \pi\, G\left[\tau\right]\right\}^{\psi} \tag{B.4-6}$$

Differentiating equation (B.4-6) with respect to τ and rearranging, we obtain the following equation determining the optimal τ implicitly,

$$\tau^* = \left(1 - \frac{\kappa / \psi}{(1-\Gamma[\tau^* : \tau^f])}\right)\left(\frac{(1-\pi^f)}{\pi}\right). \tag{B.4-7}$$

where Γ is the elasticity of output with respect to the capital tax rate (reflecting both the sensitivity of capital flows to the capital tax rate and output to the capital stock; see equation (3b) for further details). Assume that Γ is constant. In this case, equation (B.4-7) has the reasonable properties that the optimal capital income tax rate depends (1) negatively on the relative utility weight on private goods (κ / ψ), (2) negatively on the share of capital income (thus requiring a lower capital tax rate to collect a given amount of revenue), and (3) negatively on Γ (reflecting the amount of capital outflow for a given change in τ).

Differentiating equation (B.4-7) with respect to τ and τ^f with the chain rule and rearranging yields the following reaction function,

$$\frac{d\tau}{d\tau^f} = \frac{\delta^* \Gamma'}{\left(1+\delta^* \Gamma'\right)}, \tag{B.4-8a}$$

$$\delta \equiv \left(\kappa / \psi\right)\left((1-\pi^f)/\pi\right)\left(1-\Gamma[.]\right)^{-2} > 0, \tag{B.4-8b}$$

$$\Gamma' \equiv d\Gamma / d\tau. \tag{B.4-8c}$$

Relative to our preferred reaction function derived from an indirect utility function, equation (B.4-8) is restrictive because its sign depends on the direction of change in an elasticity, a derivative that is unrelated to traditional economic mechanisms and intuition. Note that, if the production and capital flow functions constituting Γ have constant elasticities, then $\Gamma' = 0$ and $d\tau / d\tau^f > 0$. Most importantly, the direct utility model does not allow for the possibility that the public/private good mix is sensitive to income. Such a restriction is relaxed in the indirect utility model and proves very important in understanding the slope of the reaction function.

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Appendix C: Variable Definitions and Data Sources[5]

This appendix describes the construction of and data sources for the variables used in this study:

1. ACT: Average Corporate Tax Rate
2. CAW: Capital Apportionment Weight
3. CIT: Corporate Income Tax Rate
4. EXPS: State government expenditures share of state GDP
5. GDP (and GDPGROWTH): State Gross Domestic Product (and its growth rate)
6. ITC: Investment Tax Credit Rate
7. MFGSHR: Manufacturing share of state GDP
8. PERS: Personal Income Tax Rate
9. PREFERENCES: Voter Preferences
10. POPULATION (and POP20-64): Total Population (and population 20-64 years old)
11. TAXREV: Corporate tax revenue share of state GDP
12. TD: Tax Depreciation
13. TWC: Tax wedge on capital
14. $\omega_{i,j}$: Spatial Lag Weights
15. Legend

The series are for the 48 contiguous states (indexed by subscript s) for the period 1963 to 2006 (indexed by subscript *t*), unless otherwise noted.[6] Each of the above series is described in a separate section. The general organizing principle for each section is to first define each of the series mentioned above and then discuss its components. For each component, general issues concerning the construction of the series (if pertinent) and then data sources are discussed. Section 11 contains a Legend with abbreviations and sources.

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[5] In describing the raw data, we have taken some of the text in this data appendix directly from government publications.

[6] The most notable exception is that the Annual Survey of Manufacturers was not conducted from 1979 to 1981.

1. ACT: Average Corporate Tax Rate

The average corporate tax rate is measured as follows,

$$ACT_{i,t} = REV_{i,t}^{CIT} \Big/ GOS_{i,t} ,$$

where $GOS_{i,t}$ is state private gross operating surplus and $REV_{i,t}^{CIT}$ is state government revenues from the corporate income tax.

Gross operating surplus data come from REA, and state tax revenues data comes from STC.

2. CAW: Capital Apportionment Weight

The capital apportionment weight (CAW) is the weight that the state assigns to capital (property) in its formula apportioning income among the multiple states in which firms generate taxable income. The apportionment formula is always a weighted average of the company's sales, payroll, and property (with zero weights allowed). However, the weights vary by state. In practice, the payroll and property weights are always equal, at least for the states and years in our sample, so that knowing one of the three weights for a state reveals the other two.

We construct data from 1963 – 2006 on the factor apportionment weights for each of the 48 contiguous states. We use a number of different sources. OMER provides information on the year in which each state first deviated from the traditional three-factor, equal weighting formula. Kelly Edmiston kindly provided data on apportionment weights for years 1997 and 2001 used in CESW. John Deskins kindly provided data panel data for 1985-2003 used in BDF. Lastly, we were able to obtain weights for various years from STH.

3. CIT: Corporate Income Tax Rate

The effective corporate income tax rate at the state level ($\tau_{i,t}^{E,S}$) is lower than the legislated (or statutory) corporate income tax rate ($\tau_{t}^{L,S}$) due to the deductibility (in some states) against state taxable income of taxes paid to the federal government.[7] Some states allow full deductibility of federal corporate income taxes from state taxable income; Iowa and Missouri allow only 50% deductibility; and some states allow no deductibility at all. The deductibility provision in state tax codes is represented by $\upsilon_{i,t} = \{1.0, 0.5, 0.0\}$, and the provisional effective corporate income tax rate at the state level ($\tau_{i,t}^{\#,E,S}$) is as follows,

$$\tau_{i,t}^{\#,E,S} = \tau_{t}^{L,S}\left(1 - \upsilon_{i,t}\tau_{i,t}^{\#,E,F}\right).$$

The effect of federal income tax deductibility is represented by the provisional *effective* corporate income tax rate at the federal level ($\tau_{i,t}^{\#,E,F}$, defined below).

The $\tau_{i,t}^{L,S}$ and $\upsilon_{i,t}$ series are obtained from several sources. For recent years, data are obtained primarily from various issues of BOTS and STH, as well as actual state tax forms. Data for earlier years are obtained from various issues of BOTS and SFFF. Additional information has been provided by TAXFDN. Many states have multiple legislated tax rates that increase stepwise with taxable income; we measure $\tau_{i,t}^{L,S}$ with the marginal legislated tax rate for the highest income bracket.

The effective corporate income tax rate at the federal level is lower than the legislated corporate income tax rate ($\tau_{t}^{L,F}$) due to the deductibility against federal taxable income of taxes paid to the state. The provisional effective corporate income tax rate at the federal level is as follows,

$$\tau_{i,t}^{\#,E,F} = \tau_{t}^{L,F}\left(1 - \tau_{i,t}^{\#,E,S}\right)$$

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[7] In "corporate income" taxes we also include Texas' "franchise" tax, which has a very similar tax base as the traditional corporate income tax base.

The effect of state income tax deductibility is represented by the *effective* corporate income tax rate at the state level. The $\tau_{t}^{L,F}$ series is obtained from GRAVELLE, Table 2.1. Our database presents $\tau_{t}^{L,F}$ in percentage points.

It has not generally been recognized that, owing to deductibility of taxes paid to another level of government, the effective corporate income tax rates at the state and federal levels are functionally related to each other. As shown in the above equations, these interrelationships yield two equations in two unknowns, and thus can be solved for the effective corporate income tax rates at the state and federal levels, respectively, as follows,

$$\tau_{i,t}^{E,S} = \tau_{i,t}^{L,S}\left[1-\upsilon_{i,t}\tau_{t}^{L,F}\right] \Big/ \left[1-\upsilon_{i,t}\tau_{i,t}^{L,S}\tau_{t}^{L,F}\right],$$

$$\tau_{i,t}^{E,F} = \tau_{t}^{L,F}\left[1-\tau_{i,t}^{L,S}\right] \Big/ \left[1-\upsilon_{i,t}\tau_{i,t}^{L,S}\tau_{t}^{L,F}\right].$$

The overall corporate income tax rate is the sum of $\tau_{i,t}^{E,S}$ and $\tau_{i,t}^{E,F}$. In the limiting case where federal corporate income taxes are not deductible against state taxable income ($\upsilon_{i,t}=0$), this sum reduces to the more frequently used formula, $\tau_{i,t}^{L,S}+\left(1-\tau_{i,t}^{L,S}\right)\tau_{t}^{L,F}$.

4. EXPS: State Government Expenditures As A Share Of State GDP

The numerator comes from SGF and the denominator comes from REA. Both are measured in nominal dollars.

5. GDP: State Gross Domestic Product

Data on real state gross domestic product (GDP) and its growth rate (GDPGROWTH) come from REA.

6. ITC: Investment Tax Credit Rate

The state investment tax credit is a credit against state corporate income tax liabilities. We focus on investment tax credits that are permanent. In general, the effective amount of the investment tax credit is simply the legislated investment tax credit rate ($ITC_{i,t}^{L,S}$) multiplied by the value of capital expenditures put into place within the state in a tax year. The effective rate is lower than the legislated rate in a handful of states for two reasons. First, five states (Connecticut, Idaho, Maine, North Carolina, and Ohio) permit the state investment tax credit to be applied only to equipment. Since equipment investment is approximately 85% of ASM total national investment, we multiply $ITC_{i,t}^{L,S}$ by 0.85 for these five states. Second, states generally require basis adjustments deducting the amount of the credit from the asset basis for depreciation purposes; this adjustment is considered in the subsection on the Present Value of Tax Depreciation Allowances.

We extend the 1963-2004 state panel data on $ITC_{i,t}^{L,S}$ from Chirinko and Wilson (2008) through 2006. The original and extended data are obtained directly from states' online corporate tax forms and instructions. For most states with an investment tax credit, both current and historical credit rates are provided in the current year instructions (since companies applying for a credit based on some past year's investment apply that year's credit rate rather than the current rate). In those few cases where some or all historical rates were missing from the online forms and instructions, the missing rates are obtained via direct communication with the state's department of taxation. In some states, the legislated investment tax credit rate varies by the level of capital expenditures; we use the legislated credit rate for the highest tier of capital expenditures.

7. MFGSHR: Manufacturing State GDP As A Share Of Total State GDP

The numerator and denominator come from REA. Both are measured in nominal dollars.

8. PERS: Personal Income Tax Rate

The personal income tax rate is measured by the marginal tax rate for the median household computed from the NBER TaxSim simulator. TaxSim generates the marginal state tax rate for each state-year for a hypothetical taxpayer who files jointly, has no dependents, and has household income equal to the 50th percentile nationally for that year.

9. PREFERENCES: Voter Preferences

Voter preferences are measured by political outcomes. Specifically, we measure the following two political outcomes as indicator variables:

(a) the governor is Republican (R). (The complementary class of politicians is Democrat (D) or Independent (I). An informal examination of the political landscape suggests that Independents tend to be more closely aligned with the Democratic Party. We thus treat D or I politicians as belonging to the same class, DI);

(b) the majority of both houses of the legislature are R;

The PREFERENCES variable takes on one of three values:

0 if the governor and the majority of both houses of the legislature are not R;

1/2 if the governor is R but the majority of both houses of the legislature are not R or if the governor is not R but the majority of both houses of the legislature are R;

1 if the governor and the majority of both houses of the legislature are R.

Data for these political variables come from the Statistical Abstract of the United States (U.S. Census Bureau (Various Years)).

10. POPULATION (And POP20-64): Total Population (And Population 20-64 Years Old)

Data on total population and population aged 20-64 years old are obtained from CENSUS.

11. TAXREV: Corporate Tax Revenue As A Share Of State GDP

The numerator comes from SGF and the denominator comes from REA. Both are measured in nominal dollars.

12. TD: Tax Depreciation

Tax depreciation allowances accrue over the useful life of the asset. We have assumed that the present value of tax depreciation allowances, $TD_{i,t}$, is 0.70 for all s and t. We assume a slightly lower value than the average across asset types and years reported in GRAVELLE to adjust for the basis reduction by the amount of investment tax credits taken.

13. TWC: Tax Wedge on Capital

The price of capital (tax-adjusted) is defined as the product of three objects reflecting the purchase price of the capital good, the opportunity costs of holding depreciating capital, and taxes. This latter term comprises tax credits, tax deductions, and the tax rate on income, and we refer to these tax terms (less 1.0) as the tax wedge on capital,

$$TWC_{i,t} = \frac{1.0 - ITC_{i,t} - CIT_{i,t} * TD}{1 - CIT_{i,t}} - 1.0 \ .$$

In this paper, we define $TWC_{i,t}$ only in terms of state tax variables.

Note that the user cost of capital, which was introduced by JORGENSON-1 in 1963 and extended by, among others, HALL-JORGENSON, GRAVELLE, JORGENSON-YUN, and KING-FULLERTON, equals the price of capital divided by the price of output.

14. $\omega_{i,j}$: Spatial Lag Weights

The spatial lag weights in our baseline specifications are measured by the inverse of the distance between state population centroids (data are from CENSUS). In supplemental specifications, we also use spatial weights based oncommodity trade flows (data are from TRANSPORT) and spatial weights based on population divided by distance. The population data are for the year 2000 and come from CENSUS. All spatial weighting matrices are row-normalized.

15. Legend

ASM: CENSUS, *Annual Survey of Manufactures, Complete Volume* (Various Years).

ASM-GAS: CENSUS, *Annual Survey of Manufacturers, Geographic Area Statistics* (Various Years). Publications for the years 1994 to 2004 (except 1997 and 2002) are available online. These data are published on an establishment basis. The data are obtained from electronic or paper documents depending on the time period: 2004 (Census website); 2003 to 1972 (CD's purchased from Census); 1971 to 1963 (paper copies). URL: http://www.census.gov/mcd/asm-as3.html.

ASM-SIGI: CENSUS, *Annual Survey of Manufacturers, Statistics for Industry Groups and Industries* (1996). URL: http://www.census.gov/mcd/asm-as1.html.

BDF: Bruce, Donald, Deskins, John, and Fox, William F., "On The Extent, Growth, and Efficiency Consequences of State Business Tax Planning," mimeo, University of Tennessee, 2005.

BOTS: The Council of State Governments, *The Book of the States* (The Council of State Governments : Lexington, Kentucky, Various Issues).

CBP: CENSUS, *County Business Patterns.* URL: http://www.census.gov/epcd/cbp/download/cbpdownload.html.

CENSUS: Bureau of the Census, U.S. Department of Commerce. URL: http://www.census.gov.

CESW: Cornia, Gary; Edmiston, Kelly; Sjoquist, David L.; and Wallace, Sally, "The Disappearing State Corporate Income Tax," *National Tax Journal* 58 (March 2005), 115-138.

FIXED: BEA, *Standard Fixed Asset Tables.* URL: http://www.bea.gov/bea/dn/FA2004/SelectTable.asp.

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GRAVELLE: Gravelle, Jane G., *The Economic Effects of Taxing Capital Income* (Cambridge: MIT Press, 1994) plus updates kindly provided by Jane Gravelle.

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OMER: Omer, Thomas C., and Shelley, Marjorie K., “Competitive, Political, and Economic Factors Influencing State Tax Policy Changes,” *Journal of the American Tax Association*, 26 (2004), 103-126.

REA: Bureau of Economic Analysis, *Regional Economic Accounts* URL: http://www.bea.gov/regional.

SGF: CENSUS, Survey of State Government Finances (SGF), various years. https://www.census.gov/govs/state/.

SFFF: American Council on Intergovernmental Affairs, *Significant Features of Fiscal Federalism* (Washington, DC: American Council on Intergovernmental Affairs, Various Issues). URL (e.g., 1987): http://www.library.unt.edu/gpo/ACIR/SFFF/SFFF-1988-Vol-1.pdf.

STC CENSUS, State Government Tax Collections report, various years. URL: http://www.census.gov/govs/www/statetax.html.

STH: Commerce Clearing House, *State Tax Handbook* (Chicago: Commerce Clearing House, Various Issues).

TAXFDN: Tax Foundation web site. URL: http://www.taxfoundation.org.

TRANSPORT: The U.S. Bureau of Transportation Statistics, *1997 Survey of Commodity Flows*.

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Appendix D: A Distributed Lag Reaction Function

This appendix combines a static tax reaction function with a partial adjustment model to derive the distributed lag reaction function that generates the benchmark results in this paper.

The flow of capital among states may occur gradually over several years, and hence the observed τ_t will differ from the desired home state capital income tax rate, $\tau_t^{\#}$. To allow for the gradual response of τ_t, we adopt the following partial adjustment model,

$$\tau_t = \lambda\left(\tau_t^{\#} - \tau_{t-1}\right) + \tau_{t-1} + v_t, \tag{D-1}$$

where λ is a parameter determining how much of the discrepancy between the long-run and lagged τ's will be eliminated in period t, and v_t is a stochastic shock. The *i* subscripts have been omitted for convenience. Lagging equation (D-1) one period and successively substituting the lagged equations into equation (D-1) yields the following equation,

$$\tau_t = \lambda \sum_{j=0}^{J} (1-\lambda)^j \tau_{t-j}^{\#} + \sum_{j=0}^{J} (1-\lambda)^j v_{t-j} + (1-\lambda)^{(J+1)} \tau_{t-J-1}. \tag{D-2}$$

As $J \to \infty$, the last term vanishes. We use the static relation (equation (7)) to define $\tau_t^{\#}$,

$$\tau_t^{\#} = \alpha \tau_t^f + \beta x_t + u_t. \tag{D-3}$$

Substituting equation (D-3) into (D-2) and rearranging, we obtain the following distributed lag model,

$$\tau_t = \sum_{j=0}^{\infty} \tilde{\alpha}_j \tau_{t-j}^f + \sum_{j=0}^{\infty} \tilde{\beta}_j x_{t-j} + w_t, \tag{D-4}$$

$$\tilde{\alpha}_j \equiv \lambda \alpha (1-\lambda)^j,$$

$$\tilde{\beta}_j \equiv \lambda \beta (1-\lambda)^j,$$

$$w_t \equiv \sum_{j=0}^{\infty} (1-\lambda)^j \left(v_{t-j} + \lambda u_{t-j}\right),$$

$$\sum_{j=0}^{\infty} \tilde{\alpha}_j = \lambda \alpha \sum_{j=0}^{\infty} (1-\lambda)^j = \alpha.$$

As shown on the last line of Equation (D-4), the estimated coefficients on the τ_{t-j}^f's sum to α, the slope of the reaction function that is the prime focus of this paper.

Equation (D-4) is the basis for our estimation, which relies on a less general form of this equation in three dimensions. First, the distributed lags are truncated at no more than four periods. Lagged dependent variables allow us to capture the effects of lags further back in time, and this model is discussed in Appendix F.

Second, in order to conserve degrees of freedom, we lag the x variables only one period. An implication of equation (D-4) is that the composite error term will be correlated with all of the τ^{f}_{t-j}'s, not just τ^{f}_{t}. We explore the impact of this potential correlation on the coefficients of interest by instrumenting the lagged foreign tax rate variables with lags of our preferred instrument set (i.e., for a given n, $\tau^{f}_{i,t-n}$ is instrumented by $z^{*}_{\tau,i,t-n}$ for n=1,4). (We estimate the time fixed effects model because estimation of the CCE model would be computationally demanding with this expanded number of instruments.) Standard errors increase sharply and do not permit us to make any meaningful inferences. This result is traceable to a small amount of incremental information in $z^{*}_{\tau,i,t-n}$ relative to $z^{*}_{\tau,i,t}$. The eigenvalue for assessing instrument relevance is less than one for each model (i.e., n=1, 2, 3, and 4), far below the conventional critical value of 11.29 (see Section IV.C). Our instruments do not have sufficient variation to accurately discriminate among lagged τ^{f}_{t-j}'s.

Third, we do not impose the parametric restrictions on the $\tilde{\alpha}_j$'s and $\tilde{\beta}_j$'s in equation (D-4). While efficiency would be enhanced, a less restricted specification continues to generate unbiased and consistent estimates. We prefer a less restricted form to facilitate computation of the CCE estimator and our instrument search algorithm.

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Appendix E: The Three-Step Procedure For Estimating The Non-Linear CCE Model

This appendix presents a more concise and formal statement of our three-step procedure for obtaining consistent estimates with the non-linear CCE estimator described in Sections IV.B and IV.D. We begin by reproducing equation (10) as equation (E-1),

$$\begin{aligned}\tau_{i,t} &= \alpha_0 \hat{\tau}^{f}_{i,t} + \sum_{n=1}^{N} \alpha_n \tau^{f}_{i,t-n} + x_{i,t}\beta + \varphi_i + \varepsilon_{i,t} \\ &\quad + \gamma_i \left(\bar{\tau}_t - \alpha_0 \bar{\hat{\tau}}^{f}_{t} - \sum_{n=1}^{N} \alpha_n \bar{\tau}^{f}_{t-n} - \bar{x}_t \beta \right),\end{aligned} \tag{E-1}$$

and rewriting it in the following concise notation,

$$\begin{aligned}\tau_{i,t} &= Q\left[\Pi^m, \Omega^n, \gamma^o\right] \\ \Pi^m &= \left\{\text{all } \alpha_i \text{ 's and } \beta \text{ from the first line in equation (E-1)}\right\} \\ \Omega^n &= \left\{\text{all } \alpha_i \text{ 's and } \beta \text{ from the second line in equation (E-1)}\right\} \\ \gamma^o &= \left\{\text{all } \gamma_i \text{ 's}\right\}\end{aligned} \tag{E-2}$$

where the m, n, and o superscripts index iterations.

Step 1 estimates the Π and Ω parameters pre-setting γ to 1.0,

$$\tau_{i,t} = Q\left[\Pi^1, \Omega^1, \gamma^o = 1\right]. \tag{E-3}$$

Step 2 estimates the Π and γ parameters pre-setting the Ω parameters to the estimates obtained in Step 1,

$$\tau_{i,t} = Q\left[\Pi^2, \Omega^1, \gamma^2\right], \tag{E-4}$$

and then iterates as follows,

$$\begin{aligned}\tau_{i,t} &= Q\left[\Pi^3, \Omega^2, \gamma^3\right], \\ \tau_{i,t} &= Q\left[\Pi^4, \Omega^3, \gamma^4\right],\end{aligned} \tag{E-5}$$

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until converge is achieved for each individual hth parameter $\pi_h \in \Pi$ and $\omega_h \in \Omega$ according to the following convergence criteria at the pth iteration,

$$\left| \pi_h^p / \omega_h^p - 1 \right| \le 0.01. \tag{E-6}$$

Step 3 estimates the Π and Ω parameters pre-setting the γ parameters to the consistent estimates obtained at the conclusion of Step 2,

$$\tau_{i,t} = Q\left[\Pi^{p+1}, \Omega^{p+1}, \gamma^{p}\right]. \tag{E-7}$$

Equation (E-7) is linear in the parameters and is the basis for the CCE estimates presented in the paper.

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Appendix F: Notes on the Specification of Dynamic Models

This appendix provides the details supporting our discussion in Section V.D that A) the standard lagged dependent variable (LDV) model is nested within a more general dynamic model that includes no LDV but an infinite number of time lags of the independent variables and B) a restricted version of this latter model can be estimated by including *N* lags of the independent variables and the *N+1st* lag of the LDV.

An "expanded" specification of our preferred model includes lags of all independent variables and is written as follows,

$$\tau_t = \sum_{n=0}^{N} \left(x_{t-n} \beta_n \right) + \varepsilon_t \tag{F-1}$$

where one of the variables in the x vector is the spatial lag of τ and *N* can go to infinity. (Note state subscripts have been omitted for expositional convenience.) Equation (F-1) is more general than our preferred specification in equation (10) because it contains additional lags. Equation (10) can be obtained from equation (F-1) by setting $\beta_n = 0$ for $n \geq 1$ in equation (F-1) and $\varphi_i = \varepsilon_{i,t} = \gamma_i = 0$ in equation (10).

Now consider the lagged dependent variable (LDV) model:

$$\tau_t = \rho\tau_{t-1} + x_t\beta + \vartheta_t\,, \tag{F-2}$$

where ϑ_t is an error term. The LDV can be eliminated by lagging this equation one period and substituting it into equation (F-2). The resulting equation contains the regressors x_t, x_{t-1}, and τ_{t-2}. The latter variable is eliminated by repeating the above procedure by lagging this transformed equation one period. If the procedure is repeated up to the *N+1st* period, we obtain the following equation,

$$\tau_t = \rho^{N+1}\tau_{t-N-1} + \sum_{n=0}^{N} \left(x_{t-n}\, \gamma_n \right) + \varepsilon_t\,, \tag{F-3a}$$

$$\gamma_n = \rho^n \beta\,, \tag{F-3b}$$

$$\varepsilon_t = \sum_{n=0}^{N} \rho^n\, \vartheta_{t-n}\,. \tag{F-3c}$$

The only important difference between our preferred model (equation (F-1)) and the LDV model (equation (F-3)) is the LDV term $\rho^{N+1}\tau_{t-N}$. (The less important differences involve redefining the coefficient vector on the x variables (equation (F-3b)) and the serial correlation in the error term (equation (F-3c).) The central point is that what we are omitting from our model is NOT last year's tax policy (τ_{t-1}), since the effects of this term are captured by the one-year lags of the x variables (and lagged error terms), but rather a term capturing the determinants of tax policy lagged more than *N* periods in the past. (The serial correlation in the error term does not pose any bias problems as long as the x variables are exogenous or instrumented.)

As *N* goes to infinity, ρ^{N+1} goes to zero, and the LDV term vanishes. It is in this sense that the LDV model is nested within a more general model with an infinite number of lags of x_{t-n}. In practice, the question of whether our omission of the LDV term from our estimating equation poses any problem depends on how far back lags of x_{t-n} could reasonably be expected to affect tax policy. The results presented in the paper for models without an LDV are based on a maximum lag of N=4. However, we also have estimated a model in which we set N=3 and then include the dependent variable lagged four periods (i.e., the term $\rho^{3+1}\tau_{t-3-1}$. These results are discussed briefly in Section V.D.