Appendix

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A New Approach to Evaluating the Welfare Effects of Decentralized Policies

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Abstract

This online appendix derives the mathematical proofs, extends the baseline model, explains our empirical applications in detail and provides additional empirical material. Appendix A formally derives the MVPF formulas. Appendix B discusses related welfare measures, including how the local and social MVPF map to welfare, and most importantly, the welfare interpretation of the MCT. It also establishes conditions when welfare weights are not necessary to construct the MCT. Appendix C includes supplementary material for our recipe book, including derivations of the material presented in the text. Appendix D shows how our general framework can be quantified and utilized, using the examples of education spending and property tax cuts. Appendix E includes additional material related to the empirical applications.

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Appendix A

Derivations of the Local and Social MVPF Formulas

This appendix provides proofs deriving the local and social MVPF formulas reported in (3), including all of their components. To this aim, recall that in the spatial general equilibrium all endogenous variables in each jurisdiction j are functions of the policy instruments in all of all the jurisdictions of the economy. Specifically, in jurisdiction j the equilibrium level of the local wage, $w_j^\star \equiv \pi_j(\mathbb{P})$, the housing price/rent, $p_j^\star \equiv \pi_j(\mathbb{P})$, the population, $n_j^\star \equiv \pi_j(\mathbb{P})$, the number of firms, $m_j^\star \equiv \pi_j(\mathbb{P})$, the individual numéraire consumption, $x_j^\star \equiv \pi_j(\mathbb{P})$, the individual housing demand, $h_j^\star \equiv \pi_j(\mathbb{P})$, the individual labor supply, $\ell_j^\star \equiv \pi_j(\mathbb{P})$, the firm profit in the numéraire sector, $\pi_j^\star \equiv \pi_j(\mathbb{P})$, the profit of the housing sector, $\pi_j^{h\star} \equiv \pi_j(\mathbb{P})$, are all functions of the aggregate policy instrument set $\mathbb{P} \equiv (P_1, \ldots, P_I)$, which includes the local policy instrument set of all jurisdictions $i = 1, \ldots, I$, $P_i \equiv \{t_i^x, t_i^\ell, t_i^h, t_i^n, t_i^\pi, g_i, z_i\}$. As governments may strategically respond to each other's policies, the policy instruments of jurisdiction i, $\mathbb{P}_i$, is a function of the policies of the other jurisdictions, $\mathbb{P}_j$, $j \neq i$. Appendix A.1 derives the general expressions of the local, external and social marginal willingness to pay. Appendix A.2 derives the general expressions of the local, external and social marginal net government costs.

A.1. Local and External Marginal Willingness to Pay

The marginal willingness to pay, $WTP_{\tau_i}^j$, is a measure equal to the aggregate amount of money that the n_j current residents of jurisdiction j (that may be i itself) are willing to pay for jurisdiction i to change τ_i by one unit. Formally, it is defined as $WTP_{\tau_i}^j \equiv (n_j/\lambda_j)\partial V_j/\partial \tau_i$, where $\lambda_j \equiv \partial V_j/\partial y_j$ is the marginal utility of income of the residents of j.[1] To derive the expression of $WTP_{\tau_i}^j$, notice that using the individual budget constraint, the equilibrium indirect utility (2) can be written as:[2]

$$V_j^\star = U\left(\frac{1}{1+\mathbb{t}_j^x}\left[y_j^\star + (1-\mathbb{t}_j^\ell)w_j^\star \ell_j^\star - p_j^\star h_j^\star - \mathbb{t}_j^n\right], h_j^\star, \ell_j^\star, \mathbf{g}, e_j\right) \tag{A.1}$$

[1] Expression (A.1) makes it clear that $\lambda_j = \frac{\partial V_j}{\partial y} = \frac{1}{1+\mathbb{t}_j^x}\frac{\partial U_j}{\partial x_j}$, that is, one additional income unit given to the resident of jurisdiction j allows her to consume $1/(1+\mathbb{t}_j^x)$ units of the numéraire good and thus increases her utility by $1/(1+\mathbb{t}_j^x) \times \partial U_j/\partial x_j$ units.

[2] Alternatively, derivation of the following formulas can be done by expressing the indirect utility function as a function of the prices and income $V_j(p_j, w_j, y_j)$ and applying Roy's identity when differentiating with respect to policy instruments. However, the proofs are less economically insightful.

where the individual non-labor income is defined as in (1):

$$y_j^\star = \eta_j + \frac{1}{n_j}\sum_k \left[(1-\mathbb{t}_k^\pi)m_k\pi_k^\star\theta_{jk} + \pi_k^{h\star}\theta_{jk}^h\right]. \tag{A.2}$$

Also recall that the profit functions in the numéraire and housing sector are respectively:

$$\pi_k^\star = f_k(l_k^\star, \mathbf{z}_k) - w_k l_k^\star, \qquad\qquad \pi_k^{h\star} = (1-\mathbb{t}_k^h)p_k^\star H_k^\star - c_k^h(H_k^\star), \tag{A.3}$$

where the "star" superscript indicates that the variable is a function of the policy vector $\mathbf{P}$ including $\tau_i \in \{t_i^x, t_i^\ell, t_i^h, t_i^n, t_i^\pi, g_i, z_i\}$. Given that the MVPF involves the initial ownership distribution of the infra-marginal residents, n_j, m_k, θ_j and θ_{jk}^h are treated as exogenous, so that they appear in (A.2) without a star. Hereafter, we consider the effects on the local and external marginal willingness to pay and net government costs of a small policy change $\mathrm{d}\tau_i$.

Differentiating utility (A.1) with respect to τ_i, we obtain:

$$\frac{\partial V^j}{\partial \tau_i} = \frac{\partial U^j}{\partial x_j}\frac{\partial}{\partial \tau_i}\left(\frac{1}{1+\mathbb{t}_j^x}\left[y_j + (1-\mathbb{t}_j^\ell)w_j\ell_j - p_j h_j - \mathbb{t}_j^n\right]\right) + \frac{\partial U^j}{\partial h_i}\frac{\partial h_j}{\partial \tau_i} + \frac{\partial U^j}{\partial \ell_j}\frac{\partial \ell_j}{\partial \tau_i} + \sum_o \frac{\partial U^j}{\partial g_o}\frac{\partial g_o}{\partial \tau_i},$$

recalling that $\mathbf{g} = (g_1, \dots, g_i, \dots, g_I)$ and that g_o, $\ell \neq o$ depends on τ_i as governemnt o may strategically respond to government i's policy. Also notice that the stars are suppressed to alleviate notational complexity. Then differentiating the terms in the brackets we obtain:

$$\begin{aligned}\frac{\partial V^j}{\partial \tau_i} =& \frac{1}{1+\mathbb{t}_j^x}\frac{\partial U^j}{\partial x_j}\left(\frac{\partial}{\partial \tau_i}\left[y_j + (1-\mathbb{t}_j^\ell)w_j\ell_j - p_j h_j - \mathbb{t}_j^n\right] - \frac{y_j + (1-\mathbb{t}_j^\ell)w_j\ell_j - p_j h_j - \mathbb{t}_j^n}{1+\mathbb{t}_j^x}\frac{\partial \mathbb{t}_j^x}{\partial \tau_i}\right)\\ &+ \frac{\partial U^j}{\partial h_i}\frac{\partial h_j}{\partial \tau_i} + \frac{\partial U^j}{\partial \ell_j}\frac{\partial \ell_j}{\partial \tau_i} + \sum_o \frac{\partial U^j}{\partial g_o}\frac{\partial g_o}{\partial \tau_i},\end{aligned}$$

where $\partial \mathbb{t}_j^x/\partial\tau_i = \partial t_j^x/\partial\tau_i$ because $\mathbb{t}_j^b = t_j^b + T_j^b$ for any $b = x, \ell, h, n, \pi$. Using the household budget constraint:

$$\frac{\partial V^j}{\partial \tau_i} = \lambda_j\left(\frac{\partial}{\partial \tau_i}\left[y_j + (1-\mathbb{t}_j^\ell)w_j\ell_j - p_j h_j - \mathbb{t}_j^n\right] - x_j\frac{\partial t_j^x}{\partial \tau_i}\right) + \frac{\partial U^j}{\partial h_i}\frac{\partial h_j}{\partial \tau_i} + \frac{\partial U^j}{\partial \ell_j}\frac{\partial \ell_j}{\partial \tau_i} + \sum_o \frac{\partial U^j}{\partial g_o}\frac{\partial g_o}{\partial \tau_i},$$

recalling the definition of the marginal utility of income of the residents of j, $\lambda_j = (1/1+\mathbb{t}_j^x) \times$

$(\partial U_j/\partial x_j) = \partial V_j/\partial y_j$. Applying the product rule and collecting terms, we obtain:

$$\begin{aligned}\frac{\partial V^j}{\partial \tau_i} =& \lambda_j \left(\frac{\partial y_j}{\partial \tau_i} + (1-\mathbb{t}_j^\ell)\frac{\partial w_j}{\partial \tau_i}\ell_j - \frac{\partial p_j}{\partial \tau_i}h_j - \frac{\partial t_j^n}{\partial \tau_i} - w_j\ell_j\frac{\partial t_j^\ell}{\partial \tau_i} - x_j\frac{\partial t_j^x}{\partial \tau_i} + \frac{1}{\lambda_j}\sum_o \frac{\partial U^j}{\partial g_o}\frac{\partial g_o}{\partial \tau_i}\right) \\ &+ \left(\frac{\partial U^j}{\partial h_i} - \lambda_j p_j\right)\frac{\partial h_j}{\partial \tau_i} + \left(\frac{\partial U^j}{\partial \ell_j} - \lambda_j(1-\mathbb{t}_j^\ell)w_j\right)\frac{\partial \ell_j}{\partial \tau_i},\end{aligned}$$

where the last two terms equal zero as they correspond to the household's first-order conditions (envelope theorem), so that:

$$\frac{n_j}{\lambda_j}\frac{\partial V^j}{\partial \tau_i} = n_j\frac{\partial y_j}{\partial \tau_i} + (1-\mathbb{t}_j^\ell)\frac{\partial w_j}{\partial \tau_i}L_j - \frac{\partial p_j}{\partial \tau_i}H_j - \frac{\partial t_j^n}{\partial \tau_i}n_j - w_jL_j\frac{\partial t_j^\ell}{\partial \tau_i} - n_jx_j\frac{\partial t_j^x}{\partial \tau_i} + \frac{n_j}{\lambda_j}\sum_o \frac{\partial U^j}{\partial g_o}\frac{\partial g_o}{\partial \tau_i} \tag{A.4}$$

where all the terms have been multiplied by n_j, and recalling that $H_j = n_jh_j$ and $L_j = n_j\ell_j$ from the clearing conditions of the housing and labor markets. We now need the expression of the marginal effect on the non-labor income $\partial y_j/\partial \tau_i$. Differentiating (A.2), we obtain:

$$n_j\frac{\partial y_j}{\partial \tau_i} = \sum_k \left[(1-\mathbb{t}_k^\pi)m_k\theta_{jk}\frac{\partial \pi_k}{\partial \tau_i} + \theta_{jk}^h\frac{\partial \pi_k^h}{\partial \tau_i}\right].$$

First, recalling that the production function $f_k(l_k, \mathbf{z}_k)$ is a function of local employment, l_k, and of the public input vector $\mathbf{z}_k = (z_1, \dots, z_I, Z_k)$ where z_j are local public input provisions and Z_k is the exogenous supply of public inputs by upper governments. It follows that:

$$\frac{\mathrm{d}f_k}{\mathrm{d}\tau_i} = \frac{\partial f_k}{\partial l_k}\frac{\partial l_k}{\partial \tau_i} + \sum_o \frac{\partial f_k}{\partial z_o}\frac{\partial z_o}{\partial \tau_i}, \tag{A.5}$$

Then, plugging in the expression of the profit functions (A.3) and applying the chain rule, we obtain:

$$\begin{aligned}n_j\frac{\partial y_j}{\partial \tau_i} = \sum_k \Bigg[&(1-\mathbb{t}_k^\pi)m_k\theta_{jk}\left(\sum_o \frac{\partial f_k}{\partial z_o}\frac{\partial z_o}{\partial \tau_i} - \frac{\partial w_k}{\partial \tau_i}l_k\right) + (1-\mathbb{t}_k^\pi)m_k\theta_{jk}\left(\frac{\partial f_k}{\partial l_k} - w_k\right)\frac{\partial l_k}{\partial \tau_i} \\ &+ \theta_{jk}^h\left((1-\mathbb{t}_k^h)\frac{\partial p_k}{\partial \tau_i}H_k - p_kH_k\frac{\partial t_k^h}{\partial \tau_i}\right) + \theta_{jk}^h\frac{\partial}{\partial \tau_i}\left((1-\mathbb{t}_k^h)p_k - c_k^h\right)\frac{\partial H_k}{\partial \tau_i}\Bigg]\end{aligned} \tag{A.6}$$

where the last two terms of each row are equal to zero because they correspond to the firms' first-order conditions (envelope theorem), so that:

$$n_j \frac{\partial y_j}{\partial \tau_i} = \sum_k \left[(1-\mathfrak{t}_k^\pi) m_k \theta_{jk} \left(\sum_o \frac{\partial f_k}{\partial z_o} \frac{\partial z_o}{\partial \tau_i} - \frac{\partial w_k}{\partial \tau_i} l_k \right) + \theta_{jk}^h \left((1-\mathfrak{t}_k^h) \frac{\partial p_k}{\partial \tau_i} H_k - p_k H_k \frac{\partial t_k^h}{\partial \tau_i} \right) \right] \quad \text{(A.7)}$$

Expanding terms:

$$n_j \frac{\partial y_j}{\partial \tau_i} = \sum_k (1-\mathfrak{t}_k^\pi) m_k \theta_{jk} \sum_o \frac{\partial f_k}{\partial z_o} \frac{\partial z_o}{\partial \tau_i} - \sum_k (1-\mathfrak{t}_k^\pi) m_k \theta_{jk} \frac{\partial w_k}{\partial \tau_i} l_k + \sum_k \theta_{jk}^h (1-\mathfrak{t}_k^h) \frac{\partial p_k}{\partial \tau_i} H_k - \sum_k \theta_{jk}^h p_k H_k \frac{\partial t_k^h}{\partial \tau_i}$$

Inserting this expression into (A.4) and multiplying by $\mathrm{d}\tau_j$, it follows that for all $j = i$ or $j \neq i$:

$$WTP_{\tau_i}^j = \frac{n_j}{\lambda_j} \frac{\partial V^j}{\partial \tau_i} \times \mathrm{d}\tau_i = \text{DE}_{\tau_i}^j + \text{IE}_{\tau_i}^j + \text{OE}_{\tau_i}^j \quad \text{(A.8)}$$

where the direct effects, disposable income effects and the ownership effects are defined as follows.

Firstly, the disposable income effects and the ownership effects are, or any $j = i$ or $j \neq i$:

$$\text{IE}_{\tau_i}^j = \left((1-\mathfrak{t}_j^\ell) L_j \frac{\partial w_j}{\partial \tau_i} - H_j \frac{\partial p_j}{\partial \tau_i} \right) \times \mathrm{d}\tau_i, \quad \text{(A.9)}$$

$$\text{OE}_{\tau_i}^j = \left(\sum_k \theta_{jk}^h (1-\mathfrak{t}_k^h) \frac{\partial p_k}{\partial \tau_i} H_k - \sum_k (1-\mathfrak{t}_k^\pi) m_k \theta_{jk} \frac{\partial w_k}{\partial \tau_i} l_k \right) \times \mathrm{d}\tau_i \quad \text{(A.10)}$$

which proves the expressions of these two effects, (8) and (9), reported in the main text.

Secondly, the direct effect takes different forms depending on the policy change and on whether this effect is local and external. The general expression of the local direct effect is:

$$\begin{aligned} \text{DE}_{\tau_i}^i = & - \left(n_i \frac{\partial t_i^n}{\partial \tau_i} + w_i L_i \frac{\partial t_i^\ell}{\partial \tau_i} + n_i x_i \frac{\partial t_i^x}{\partial \tau_i} + \theta_{ii}^h p_i H_i \frac{\partial t_i^h}{\partial \tau_i} \right) \times \mathrm{d}\tau_i \\ & + \left(\frac{n_i}{\lambda_i} \frac{\partial U^i}{\partial g_i} \frac{\partial g_i}{\partial \tau_i} + \sum_k (1-\mathfrak{t}_k^\pi) m_k \theta_{ik} \frac{\partial f_k}{\partial z_i} \frac{\partial z_i}{\partial \tau_i} \right) \times \mathrm{d}\tau_i, \end{aligned} \quad \text{(A.11)}$$

where for each policy instrument $\kappa_i = t_i^n, t_i^\ell, t_i^x, g_i, z_i$, the derivative $\partial\kappa/\partial\tau_i$ is equal to 1 if $\kappa_i = \tau_i$ and zero otherwise. Indeed, jurisdiction i only changes the policy instrument which represents the exogenous policy of interest, $\mathrm{d}\tau_i$. Explicitly, (A.11) implies:

$$\text{DE}_{t_i^n}^i = -n_i \times \mathrm{d}t_i^n, \qquad \text{DE}_{t_i^\ell}^i = -w_i L_i \times \mathrm{d}t_i^\ell, \qquad \text{DE}_{t_i^x}^i = -n_i x_i \times \mathrm{d}t_i^x, \quad \text{(A.12)}$$

$$\text{DE}_{t_i^h}^i = -\theta_{ii}^h p_i H_i \times \mathrm{d}t_i^h, \quad \text{DE}_{g_i}^i = \frac{n_i}{\lambda_i} \frac{\partial U^i}{\partial g_i} \times \mathrm{d}g_i, \quad \text{DE}_{z_i}^i = \sum_k (1-\mathfrak{t}_k^\pi) m_k \theta_{ik} \frac{\partial f_k}{\partial z_i} \times \mathrm{d}z_i. \quad \text{(A.13)}$$

The external direct effects are similar although they do not include the effects on local taxes. Thus, we have for any jurisdiction $j \neq i$:

$$\text{DE}^j_{\tau_i} = -\theta^h_{ji} p_i H_i \frac{\partial t^h_i}{\partial \tau_i} \times \mathrm{d}\tau_i + \left(\frac{n_j}{\lambda_j} \frac{\partial U^j}{\partial g_i} \frac{\partial g_i}{\partial \tau_i} + \sum_k (1 - \mathfrak{t}^\pi_k) m_k \theta_{jk} \frac{\partial f_k}{\partial z_i} \frac{\partial z_i}{\partial \tau_i} \right) \times \mathrm{d}\tau_i, \tag{A.14}$$

Explicitly, (A.14) implies, for any $j \neq i$:

$$\text{DE}^j_{t^n_i} = 0, \qquad \text{DE}^j_{t^\ell_i} = 0, \qquad \text{DE}^j_{t^x_i} = 0, \tag{A.15}$$

$$\text{DE}^j_{t^h_i} = -\theta^h_{ji} p_i H_i \times \mathrm{d}t^h_i, \qquad \text{DE}^j_{g_i} = \frac{n_j}{\lambda_j} \frac{\partial U^j}{\partial g_i} \times \mathrm{d}g_i, \qquad \text{DE}^j_{z_i} = \sum_k (1 - \mathfrak{t}^\pi_k) m_k \theta_{jk} \frac{\partial f_k}{\partial z_i} \times \mathrm{d}z_i. \tag{A.16}$$

In sum, expressions (A.12), (A.13), (A.15), and (A.16) prove the expressions of the direct effects stated in the main text in (7).

Thirdly, the local competitive direct effect of the policy of jurisdiction i on its own residents' WTP is:

$$\text{CDE}^i_{\tau_i} = -\sum_{o \neq i} \theta^h_{io} p_o H_o \frac{\partial t^h_o}{\partial \tau_i} \times \mathrm{d}\tau_i + \left(\sum_{o \neq i} \frac{n_i}{\lambda_i} \frac{\partial U^i}{\partial g_o} \frac{\partial g_o}{\partial \tau_i} + \sum_{o \neq i} \sum_k (1 - \mathfrak{t}^\pi_k) m_k \theta_{ik} \frac{\partial f_k}{\partial z_o} \frac{\partial z_o}{\partial \tau_i} \right) \times \mathrm{d}\tau_i,$$

or equivalently:

$$\text{CDE}^i_{\tau_i} = \left(\sum_{o \neq i} \frac{\text{DE}^i_{t^h_o}}{\mathrm{d}t^h_o} \frac{\partial t^h_o}{\partial \tau_i} + \sum_{o \neq i} \frac{\text{DE}^i_{g_o}}{\mathrm{d}g_o} \frac{\partial g_o}{\partial \tau_i} + \sum_{o \neq i} \frac{\text{DE}^i_{z_o}}{\mathrm{d}z_o} \frac{\partial z_o}{\partial \tau_i} \right) \times \mathrm{d}\tau_i, \tag{A.17}$$

which is the general expression of the local competitive direct effect. This effect is nonzero only if the jurisdiction's policy instruments generate direct external effects. Indeed, if the residents of i do not own properties in jurisdiction o, $\text{DE}^i_{t^h_o} = 0$, if they do not directly consume the public services provided in o, $\text{DE}^i_{g_o} = 0$, and if the firm located in i do not utilize public inputs provided in o, $\text{DE}^i_{z_o} = 0$. In sum, in the absence of direct external effects:

$$\text{CDE}^i_{\tau_i} = 0, \tag{A.18}$$

as stated in the main text.

The external direct effects are, for $j \neq i$:

$$\begin{aligned}\text{CDE}^j_{\tau_i} = &- \left(n_j \frac{\partial t^n_j}{\partial \tau_i} + w_j L_j \frac{\partial t^\ell_j}{\partial \tau_i} + n_j x_j \frac{\partial t^x_j}{\partial \tau_i} + \sum_{o \neq i} \theta^h_{jo} p_o H_o \frac{\partial t^h_o}{\partial \tau_i} \right) \times \mathrm{d}\tau_i \\ &+ \left(\sum_{o \neq i} \frac{n_j}{\lambda_j} \frac{\partial U^j}{\partial g_o} \frac{\partial g_o}{\partial \tau_i} + \sum_{o \neq i} \sum_k (1 - \mathfrak{t}^\pi_k) m_k \theta_{jk} \frac{\partial f_k}{\partial z_o} \frac{\partial z_o}{\partial \tau_i} \right) \times \mathrm{d}\tau_i,\end{aligned}$$

or equivalently, for $j \neq i$:

$$\text{CDE}^j_{\tau_i} = \left(\sum_{\phi_j \in \Phi_j} \frac{\text{DE}^j_{\phi_j}}{\mathrm{d}\phi_j} \frac{\partial \phi_j}{\partial \tau_i} + \sum_{o \neq i,j} \frac{\text{DE}^j_{t^h_o}}{\mathrm{d}t^h_o} \frac{\partial t^h_o}{\partial \tau_i} + \sum_{o \neq i,j} \frac{\text{DE}^j_{g_o}}{\mathrm{d}g_o} \frac{\partial g_o}{\partial \tau_i} + \sum_{o \neq i,j} \frac{\text{DE}^j_{z_o}}{\mathrm{d}z_o} \frac{\partial z_o}{\partial \tau_i} \right) \times \mathrm{d}\tau_i, \tag{A.19}$$

which is the general expression of the external competitive direct effect. In the absence of direct external effects:

$$\text{CDE}^j_{\tau_i} = \sum_{\phi_j \in \Phi_j} \frac{\text{DE}^j_{\phi_j}}{\mathrm{d}\phi_j} \frac{\partial \phi_j}{\partial \tau_i} \times \mathrm{d}\tau_i, \tag{A.20}$$

because $\forall o \neq j$, $\text{DE}^j_{t^h_o} = \text{DE}^j_{g_o} = \text{DE}^j_{z_o} = 0$. This proves the expression of the external competitive direct effect stated in equation (10).

A.2. Local, External and Vertical Marginal Net Government Cost

We now derive the expressions of the local, external and vertical marginal net government costs. The marginal net government cost on jurisdiction j (that may be i itself) induced by policy change $\mathrm{d}\tau_i$ is the derivative of the net government cost of j:

$$NGC^\star_j = c_j(g_j, z_j, n^\star_1, \ldots, n^\star_I, m^\star_1, \ldots, m^\star_I) - n_j \big(t^\ell_j w^\star_j \ell^\star_j + t^h_j p^\star_j h^\star_j + t^x_j x^\star_j + t^n_j \big) - m_j t^\pi_j \pi^\star_j, \tag{A.21}$$

with respect to the policy instrument τ_i. Recall that the "star" superscript indicates that the equilibrium level of a variable is a function of the aggregate policy vector of the economy. The equilibrium level of the net cost (A.21) of jurisdiction j can be written in vector form: Differentiating (A.21) and ignoring star superscripts for simplicity, we immediately obtain:

$$NGC^j_{\tau_i} = \frac{\partial NGC_j}{\partial \tau_i} \mathrm{d}\tau_i = \text{ME}^j_{\tau_i} + \text{BE}^j_{\tau_i} + \text{PE}^j_{\tau_i} + \pi\text{E}^j_{\tau_i} + \text{LE}^j_{\tau_i} \tag{A.22}$$

where the effects are defined as follows. The local (competitive) mechanical effect are:

$$\text{ME}^i_{\tau_i} = \left[\frac{\partial c_i}{\partial g_i}\frac{\partial g_i}{\partial \tau_i} + \frac{\partial c_i}{\partial z_i}\frac{\partial z_i}{\partial \tau_i} - n_i\left(w_i\ell_i\frac{\partial t^\ell_i}{\partial \tau_i} + p_i h_i\frac{\partial t^h_i}{\partial \tau_i} + x_i\frac{\partial t^x_i}{\partial \tau_i} + \frac{\partial t^n_i}{\partial \tau_i}\right) - m_i\pi_i\frac{\partial t^\ell_i}{\partial \tau_i}\right] \times \mathrm{d}\tau_i, \quad \text{(A.23)}$$

$$\text{CME}^i_{\tau_i} = 0, \quad \text{(A.24)}$$

where $\partial\kappa_i/\partial\tau_i$ is 1 if $\kappa_i = \tau_i$, and 0 otherwise. The competitive mechanical effects are, for $j \neq i$:

$$\text{ME}^j_{\tau_i} = 0, \quad \text{(A.25)}$$

$$\text{CME}^j_{\tau_i} = \left[\frac{\partial c_j}{\partial g_j}\frac{\partial g_j}{\partial \tau_i} + \frac{\partial c_j}{\partial z_j}\frac{\partial z_j}{\partial \tau_i} - n_j\left(w_j\ell_j\frac{\partial t^\ell_j}{\partial \tau_i} + p_j h_j\frac{\partial t^h_j}{\partial \tau_i} + x_j\frac{\partial t^x_j}{\partial \tau_i} + \frac{\partial t^n_j}{\partial \tau_i}\right) - m_j\pi_j\frac{\partial t^\ell_j}{\partial \tau_i}\right] \times \mathrm{d}\tau_i, \quad \text{(A.26)}$$

The local and external behavioral, price and locational effects are, for $j = i$ or $j \neq i$:

$$\text{BE}^j_{\tau_i} = -n_j\left(t^x_j\frac{\partial x_j}{\partial \tau_i} + t^h_j p_j\frac{\partial h_j}{\partial \tau_i} + t^\ell_i w_j\frac{\partial \ell_j}{\partial \tau_i} + n_j t^\pi_j\frac{m_j}{n_j}\frac{\partial f_j}{\partial z_i}\frac{\partial z_i}{\partial \tau_i}\right) \times \mathrm{d}\tau_i, \quad \text{(A.27)}$$

$$\text{PE}^j_{\tau_i} = -\left((t^\ell_j - t^\pi_j)L_j\frac{\partial w_j}{\partial \tau_i} + t^h_j H_j\frac{\partial p_j}{\partial \tau_i}\right) \times \mathrm{d}\tau_i, \quad \text{(A.28)}$$

$$\text{LE}^j_{\tau_i} \equiv \left(\sum_k \frac{\partial c_j}{\partial n_k}\frac{\partial n_k}{\partial \tau_i} + \sum_k \frac{\partial c_j}{\partial m_k}\frac{\partial m_k}{\partial \tau_i} - r_j\frac{\partial n_j}{\partial \tau_i} - t^\pi_j\pi_j\frac{\partial m_j}{\partial \tau_i}\right) \times \mathrm{d}\tau_i \quad \text{(A.29)}$$

where $r_j \equiv t^\ell_j w_j\ell_j + t^h_j p_j h_j + t^x_j x_j + t^n_j$, and recalling that equilibrium on the labor market is $n_j\ell_j = m_j l_j \equiv L_j$ and that on the housing market is $n_j h_j = H_j$. Notice that derivation of the profit effects, $t^\pi_j m_j(\partial f_j/\partial z_i)\partial z_i/\partial\tau_i$ in (A.27), and , $t^\pi_j L_j\partial w_j/\partial\tau_i$ in (A.28), applies the envelope theorem on $\partial\pi_j/\partial\tau_i$ as in (A.7).

Finally, we derive the necessary expressions required for a researcher to account for fiscal externalities across different levels of governments. The equilibrium level of the vertical net government cost (5) of imposed on higher level governments by jurisdiction j is:[3]

$$VNGC = C\big(G, Z, n^\star_1, \ldots, n^\star_I, m^\star_1, \ldots, m^\star_I\big) - \sum_j \left[n^\star_j\big(T^\ell_j w^\star_j\ell^\star_j + T^h_j p^\star_j h^\star_j + T^x_j x^\star_j + T^n_j\big) + m^\star_j T^\pi_j \pi^\star_j\right], \quad \text{(A.30)}$$

where, again, the "star" superscript indicates that the equilibrium level of a variable is a function of the local policy instruments τ_i. Differentiating (A.30) and using, again, the envelope theorem

[3] Notice that the higher government level taxes T_j have a jurisdiction index because the local jurisdictions j may belong to states or regions setting different tax rates T_j, as is often the case in the empirical applications Appendix E.

for the profit effect, we obtain the local/external marginal net government cost in jurisdiction j resulting from a small change in the policy instrument $\tau_i \in P_i$ of jurisdiction i:

$$NGC^{\text{F}}_{\tau_i} \equiv \frac{\partial VNGC}{\partial \tau_i} = \text{BE}^{\text{F}}_{\tau_i} + \text{PE}^{\text{F}}_{\tau_i} + \pi\text{E}^{\text{F}}_{\tau_i} + \text{LE}^{\text{F}}_{\tau_i} \tag{A.31}$$

where the F superscript stands for "federal" although the formula holds for any upper-government layer, and:

$$\begin{aligned}
\text{BE}^{\text{F}}_{\tau_i} &= -\sum_j n_j \left(T^{\ell}_j w_j \frac{\partial \ell_j}{\partial \tau_i} + T^{h}_j p_j \frac{\partial h_j}{\partial \tau_i} + T^{x}_j \frac{\partial x_j}{\partial \tau_i} + T^{\pi}_j m_j \frac{\partial f_j}{\partial \tau_i} \right) \mathrm{d}\tau_i \\
\text{PE}^{\text{F}}_{\tau_i} &= -\sum_j \left((T^{\ell}_j - T^{\pi}_j) L_j \frac{\partial w_j}{\partial \tau_i} + T^{h}_j H_j \frac{\partial p_j}{\partial \tau_i} \right) \mathrm{d}\tau_i \\
\text{LE}^{\text{F}}_{\tau_i} &= -\left(\sum_j R_j \frac{\partial n_j}{\partial \tau_i} - \sum_j T^{\pi}_j \pi_j \frac{\partial m_j}{\partial \tau_i} \right) \mathrm{d}\tau_i
\end{aligned}$$

where $R_j \equiv T^{\ell} w_j \ell_j + T^{h} p_j h_j + T^{x} x_j + T^{n}$ is the overall vertical tax paid by a resident of j.

Appendix B
MCT as a Welfare Measure

In this appendix, we establish the formal links between MCT and welfare. These relationships are critical to justifying the welfare interpretation of the MCT discussed in Section 3.3. Appendix B.1 proves the important result that the MCT is a welfare-improving subsidy/tax allowing federal and state governments to fully rank order local policies based on a simple welfare criterion. Appendix B.2 shows that if the local government puts the same average social weight on individuals as the central government, computing the MCT does not require the researcher to use any social weights. In addition, Supplementary Material S.B establishes the link between between local MVPF, social MVPF and welfare.

B.1. Relationship between MCT and Welfare

If federal government transfers \$1 from project A to project B based on their $MCT's$, how is welfare affected? To derive this, we start from the most general case where different jurisdictions and different policies have different welfare weights. Recall that the MCT can be derived by equating:

$$\frac{\lambda_i LWTP_{\tau_i}}{LNGC_{\tau_i} - S_{\tau_i}} = \frac{\eta_{\tau_i} SWTP_{\tau_i}}{SNGC} \tag{B.1}$$

where λ_i is the equilibrium level of the marginal utility of income in i; and $\eta_{\tau_i} \equiv \sum_j \psi_j \lambda_j \sigma^j_{\tau_i}$ is the social weight of policy $d\tau_i$ which is calculated as the average social marginal utilities of income, $\psi_j \lambda_j$, of all the jurisdictions' representative individuals, weighted by their relative willingness to pay $\sigma^j_{\tau_i} \equiv WTP^j_{\tau_i} / \sum_k WTP^k_{\tau_i}$. Note that Supplementary Material S.B shows how social weights are used to turn a social MVPF into marginal social welfare.

Equation (B.1) is equivalent to:

$$MCT_{\tau_i} = \frac{\eta_{\tau_i} SMVPF_{\tau_i} - \lambda_i LMVPF_{\tau_i}}{\eta_{\tau_i} SMVPF_{\tau_i}}. \tag{B.2}$$

Then, to obtain a welfare metric, we can substitute for $SMVPF_{\tau_i}$and $LMVPF_{\tau_i}$ using their marginal returns to welfare per dollar from equations (S.B.6) and (S.B.13). We obtain:

$$MCT_{\tau_i} = \frac{\eta_{\tau_i} SMVPF_{\tau_i} - \lambda_i LMVPF_{\tau_i}}{\eta_{\tau_i} SMVPF_{\tau_i}} = \frac{SMW_{\tau_i} - LMW_{\tau_i}}{SMW_{\tau_i}} \tag{B.3}$$

This last expression makes the welfare interpretation of the MCT clear. The MCT is the change in social welfare net of the change in local welfare as a percent of the change in social welfare.

The interpretation of the welfare effects makes intuitive sense. By expressing welfare changes as a percent of social welfare, this is saying that the MCT increases as the "wedge" between SMW and LMW (loosely speaking, external marginal welfare) increases. In other words, we provide a higher matching rate when a greater percent of the SMW is coming externally.

In welfare terms, (B.3) states that the MCT is interpreted as the change in social welfare per dollar of social cost net of the change in local welfare per dollar of local cost. Importantly, the MCT accounts for both differences in social and local willingness to pay and social and local net government costs. Hence, for programs that have no spillover benefits on the willingness to pay ($EWTP = 0$), there is still a distinction between social and local welfare because of interjurisdictional fiscal externalities that then result in differences in local and social welfare. In the polar case, for programs with no interjurisdictional fiscal externalitiers ($ENGC = 0$), then marginal social welfare is per dollar of local costs ($LNGC$). In this case, the numerator of (B.3) reduces to the external marginal welfare, that is, the increase in welfare of all jurisdictions not enacting the policy. In cases where local programs have both spillover benefits and interjurisdictional fiscal externalities, then the MCT captures both of these and provides a welfare-based ranking of programs based upon the wedge between the two.

To see that the MCT ranks policies on the basis of welfare changes, we first consider a simple case of comparing two policies with the same LMW. We then relax this to consider the general case.

First, note that keeping constant the local marginal welfare, we have:

$$\frac{\partial MCT_{\tau_i}}{\partial SMW_{\tau_i}} = \frac{LMW_{\tau_i}}{SMW_{\tau_i}^2} > 0, \tag{B.4}$$

In other words increases in social welfare increase the MCT. This implies the following proposition.

Proposition B.1. *For two programs A_i and B_i generating the* same local marginal welfare*:*

$$MCT_{A_i} > MCT_{B_i} \iff (\textit{Subsidizing policy } A_i \textit{ relative to } B_i \\ \textit{yields a larger increase in social welfare}).$$

In other words, if the policies have the same local MVPF, the MCT ranks them in the same ordering as using SMVPF.

Now, consider the more general case, where we would like to compare all policies—including with different LMW. To understand how the MCT relates with welfare changes, totally differentiate (B.2) to obtain:

$$dMCT_{\tau_i} = -\frac{\lambda_i dLMVPF_{\tau_i}}{\eta_{\tau_i} SMVPF_{\tau_i}} + \frac{\lambda_i LMVPF_{\tau_i}}{\eta_{\tau_i} SMVPF_{\tau_i}^2} dSMVPF_{\tau_i}. \tag{B.5}$$

After rearranging terms, we can substitute for $SMVPF_{\tau_i}$ and $LMVPF_{\tau_i}$—and their corresponding derivatives—using their marginal returns to welfare per dollar from equations (S.B.6) and (S.B.13):

$$dMCT_{\tau_i} = \frac{LMW_{\tau_i}}{SMW_{\tau_i}} \left[\frac{dSMW_{\tau_i}}{SMW_{\tau_i}} - \frac{dLMW_{\tau_i}}{LMW_{\tau_i}} \right]. \tag{B.6}$$

From this we learn that comparing the MCT of policies is not simply a comparison of SMW but rather of the difference between the percent change of SMW and the percent change in LMW of the two policies. If SMVPF is positive,[4] then (B.6) is positive, so long as the term in brackets is positive. This term represents the percent change in social welfare after removing any change in local welfare, as the MCT concept assumes localities already act in their self-interest.

While the above derivation are implemented for marginal changes, we can extend to discretely compare two different policies by linearly approximating. Thus, we conclude that:

Proposition B.2. *For two programs A_i and B_i with positive SMVPF:*

$$MCT_{A_i} > MCT_{B_i} \iff (\textit{Subsidizing policy } A_i \textit{ relative to } B_i \textit{ yields a larger percentage increase in social welfare net of the percentage increase in local welfare}).$$

Then if the MCT of A is greater than the MCT of B then subsidizing policy A relative to B yields a larger in increase in social welfare after we net out the relative contribution of local welfare. This yields the welfarist interpretation of the MCT.

Another way of seeing this is to divide both sides of the equation by the percent change in LMW. Doing so yields:

$$\frac{dMCT_{\tau_i}}{dLMW_{\tau_i}/LMW_{\tau_i}} = \frac{LMW_{\tau_i}}{SMW_{\tau_i}} \left(\epsilon_{\mathrm{S,L}} - 1\right) \tag{B.7}$$

where $\epsilon_{\mathrm{S,L}} = (dSMW_{\tau_i}/SMW_{\tau_i})/(dLMW_{\tau_i}/LMW_{\tau_i})$ is the elasticity of SMW with respect to LMW. Then, the MCT is increasing if the response of SMW is greater than unit elastic.

[4] As noted in the text, like the MVPF, the MCT is only entirely transitive when SMVPF is no negative.

B.2. MCT and Social Weights

In the paper, social weights are not used to compute the MCT, because we implicitly assume that the local government puts the same average welfare weight on individuals as the central government. This appendix shows that under this canonical case, computing the MCT indeed does not require to assess any social weights. To this aim, we first need to generalize a bit our baseline framework by modelling explicitly individuals' heterogeneity within jurisdictions. Let ω be the index of an individual living in the federation, Ω_i^{L} be the set of individuals living in the locality i implementing the policy, and Ω^{S} be the set of individuals living in the federation.

As showed in Appendix B.1, the general formula of the MCT is:

$$MCT_{\tau_i} = 1 - \frac{LMW_{\tau_i}}{SMW_{\tau_i}} \tag{B.8}$$

In the presence of household heterogeneity, relation between marginal welfare and MVPF, equations (S.B.6) and (S.B.13) become:

$$LMW_{\tau_i} = \eta_{\tau_i}^{\mathrm{L}} LMVPF_{\tau_i}, \qquad SMW_{\tau_i} = \eta_{\tau_i}^{\mathrm{S}} SMVPF_{\tau_i}, \tag{B.9}$$

where the local and social welfare weights, $\eta_{\tau_i}^{\mathrm{L}}$ and $\eta_{\tau_i}^{\mathrm{S}}$, are defined as:

$$\eta_{\tau_i}^{\mathrm{L}} \equiv \sum_{\omega \in \Omega_i^{\mathrm{L}}} \psi^{\mathrm{L}}(\omega)\lambda(\omega)\sigma_{\tau_i}^{\mathrm{L}}(\omega) \qquad \eta_{\tau_i}^{\mathrm{S}} \equiv \sum_{\omega \in \Omega^{\mathrm{S}}} \psi^{\mathrm{S}}(\omega)\lambda(\omega)\sigma_{\tau_i}^{\mathrm{S}}(\omega). \tag{B.10}$$

In these equations, $\psi^{\mathrm{L}}(\omega)$ and $\psi^{\mathrm{S}}(\omega)$ are the exogenous local and federal weights on individual ω, $\lambda(\omega)$ is individual ω's marginal utility of income, and $\sigma_{\tau_i}^{\mathrm{L}}(\omega)$ and $\sigma_{\tau_i}^{\mathrm{S}}(\omega)$ are willingness-to-pay weights:

$$\sigma_{\tau_i}^{\mathrm{L}}(\omega) \equiv \frac{WTP_{\tau_i}(\omega)}{\sum_{\omega' \in \Omega_i^{\mathrm{L}}} WTP_{\tau_i}(\omega')} \qquad \sigma_{\tau_i}^{\mathrm{S}}(\omega) \equiv \frac{WTP_{\tau_i}(\omega)}{\sum_{\omega' \in \Omega^{\mathrm{S}}} WTP_{\tau_i}(\omega')}. \tag{B.11}$$

The local and social welfare weights, can be equivalently re-written as:

$$\eta_{\tau_i}^{\mathrm{L}} = \frac{1}{n_i} \sum_{\omega \in \Omega_i^{\mathrm{L}}} \psi^{\mathrm{L}}(\omega)\lambda(\omega)\widehat{\sigma}_{\tau_i}^{\mathrm{L}}(\omega) \qquad \eta_{\tau_i}^{\mathrm{S}} = \frac{1}{N} \sum_{\omega \in \Omega^{\mathrm{S}}} \psi(\omega)^{\mathrm{S}}\lambda(\omega)\widehat{\sigma}_{\tau_i}^{\mathrm{S}}(\omega), \tag{B.12}$$

where n_i is the population of the locality and N is the population of the federation, and the transformed willingness-to-pay weights, $\widehat{\sigma}^{\text{L}}_{\tau_i}(\omega)$ and $\widehat{\sigma}^{\text{S}}_{\tau_i}(\omega)$, are defined as:

$$\widehat{\sigma}^{\text{L}}_{\tau_i}(\omega) \equiv n_i \sigma^{\text{L}}_{\tau_i}(\omega) = \frac{WTP_{\tau_i}(\omega)}{\frac{\sum_{\omega' \in \Omega^{\text{L}}_i} WTP_{\tau_i}(\omega')}{n_i}}, \tag{B.13}$$

$$\widehat{\sigma}^{\text{S}}_{\tau_i}(\omega) \equiv n_i \sigma^{\text{S}}_{\tau_i}(\omega) = \frac{WTP_{\tau_i}(\omega)}{\frac{\sum_{\omega' \in \Omega^{\text{S}}} WTP_{\tau_i}(\omega')}{n_i}} \tag{B.14}$$

which represent the willingness to pay of individual ω for the policy relative to the average willingness to pay of the residents of the locality and and of the federation, respectively. Intuitively, $\widehat{\sigma}^{\text{L}}_{\tau_i}(\omega)$ and $\widehat{\sigma}^{\text{S}}_{\tau_i}(\omega)$ are valuations of the policy by individual ω relative to the residents of locality i and relative to all the residents of the federation (or state), respectively. This allows us to rewrite the welfare weights (B.12) as:

$$\eta^{\text{L}}_{\tau_i} \equiv \frac{1}{n_i} \sum_{\omega \in \Omega^{\text{L}}_i} \phi^{\text{L}}_{\tau_i}(\omega) \qquad \eta^{\text{S}}_{\tau_i} \equiv \frac{1}{N} \sum_{\omega \in \Omega^{\text{S}}} \phi^{\text{S}}_{\tau_i}(\omega) \tag{B.15}$$

where the individual welfare weights $\phi^{\text{L}}(\omega)$ and $\phi^{\text{S}}(\omega)$ are defined as:

$$\phi^{\text{L}}_{\tau_i}(\omega) \equiv \psi^{\text{L}}(\omega)\lambda(\omega)\widehat{\sigma}^{\text{L}}_{\tau_i}(\omega) \qquad \phi^{\text{S}}_{\tau_i}(\omega) \equiv \psi^{\text{S}}(\omega)\lambda(\omega)\widehat{\sigma}^{\text{S}}_{\tau_i}(\omega). \tag{B.16}$$

These are the welfare weights of individual ω by the locality and by the federation, respectively.

Two remarks must can made about the above welfare weights. First, recall that $\Omega^{\text{L}}_i \subset \Omega^{\text{S}}$ so that the welfare weights, η^{L} and η^{S}, are average weights over different populations. Second, notice that the individual welfare weights, $\phi^{\text{L}}(\omega)$ and $\phi^{\text{S}}(\omega)$ can be interpreted as being exogenously set by the local and federal government, respectively. Indeed, although these weights include endogenous elements—namely, the marginal utility of income $\lambda(\omega)$ and the relative willingness to pay, $\widehat{\sigma}^{\text{S}}_{\tau_i}$ and $\widehat{\sigma}^{\text{L}}_{\tau_i}$—they include the parametric exogenous weights $\psi^{\text{L}}(\omega)$ and $\psi^{\text{S}}(\omega)$ which can be chosen by the governemnts so that $\phi^{\text{L}}(\omega)$ and $\phi^{\text{S}}(\omega)$ take any locally/socially desired values.

In sum, the MCT of policy τ_i is defined by:

$$MCT_{\tau_i} = 1 - \frac{LMW_{\tau_i}}{SMW_{\tau_i}} = 1 - \frac{\eta^{\text{L}}_{\tau_i} LMVPF_{\tau_i}}{\eta^{\text{S}}_{\tau_i} SMVPF_{\tau_i}} \tag{B.17}$$

where $\eta^{\text{L}}_{\tau_i}$ and $\eta^{\text{S}}_{\tau_i}$ are defined as in (B.12). Hence, the expression of the MCT reduces to:

$$MCT_{\tau_i} = 1 - \frac{LMVPF_{\tau_i}}{SMVPF_{\tau_i}} \tag{B.18}$$

if the local and social weights η^{L} and η^{S} are equal, that is, if and only if:

$$\eta^{\text{L}} \equiv \quad \frac{1}{n_i} \sum_{\omega \in \Omega_i^{\text{L}}} \phi^{\text{L}}(\omega) = \frac{1}{N} \sum_{\omega \in \Omega^{\text{S}}} \phi^{\text{S}}(\omega) \quad \equiv \eta^{\text{S}}. \tag{B.19}$$

This requires that the average weight put on the beneficiaries of the policy (on individuals affected by the policy) by the locality and by the federal government need to be equal. This canonical case will reasonably hold, as discussed in the text, when the locality enacting the policy is "average."

Proposition B.3. *The welfare weights $\eta^{\text{S}}_{\tau_i}$ and $\eta^{\text{L}}_{\tau_i}$ can be ignored in quantifying the MCT if locality and the central government have same average weights on their respective populations.*

Importantly, these weights need not all be equal for each individual or each jurisdiction within the federation, but they must only be equal on average. For example, $\eta^{\text{L}} = \eta^{\text{S}}$ if (1) the federal government puts no weight on the non-residents of jurisdiction i and (2) the federal government puts exactly the same weights of each resident of i as government i does,. However, these strong conditions are not the only possibility for condition (B.19) to hold. Indeed, the federal government can put any weights on both resident of i and nonresidents of i as long the average of these weights is equal to the average weights put by government i on its own residents.

Appendix C

Toward a Recipe Book

This appendix provides a model that supplements our recipe book in Section 5. For purposes of this appendix, we define p_j as the price per unit of housing, rather than the value of a house as denoted in the text. Then, h_j is housing per resident. This general formulation will reduce to the equations in the text by letting $p_j = p_j h_j$.

Utility is potentially a function of the policies in jurisdiction i and j, wages in jurisdiction i or j (depending on where they work) and house prices where they live.

Assumption 1. *Location of residence is independent of location of work.*

Then equal utility requires that

$$U^i\left(p_i, \tau_i\right) = U^j\left(p_j, \tau_j\right), \forall\, j \neq i \tag{C.1}$$

where we suppress the argument for wages as under the assumption that location of residence is independent of location of work, in equilibrium all workers receive the same wage. Population clearing requires

$$\sum_j n_j = N. \tag{C.2}$$

where $n_j = \frac{H^s(p_j)}{h_j(p_j)}$ and $H^s\left(p_j\right)$ is supply of housing and $h_j\left(p_j\right)$ is housing per capita (household). We differentiate (C.2) giving

$$n_i \eta_i^h \widehat{p}^i_{\tau_i} = -\sum_{j \neq i} \eta_j^h n_j \widehat{p}^j_{\tau_i} \tag{C.3}$$

where $\widehat{p}^i_{\tau_i} = \frac{1}{p_j}\frac{\partial p_j}{\partial \tau_i}$, the percentage change in housing in j and $\eta_j^h = \frac{\partial n_j}{\partial p_j}\frac{p_j}{n_j}$, the elasticity of population. Note that as $n_j = \frac{H^s(p_j)}{h_j(p_j)}$ it is also the case that $\eta_j^h = \frac{\partial\left(\frac{H^s\left(p_j\right)}{h_j\left(p_j\right)}\right)}{\partial p_j}\frac{p_j}{\left(\frac{H^s\left(p_j\right)}{h_j\left(p_j\right)}\right)}$ or the elasticity of housing supply as measured in housing *units*. This makes it clear that $\eta_i^h = \epsilon_i^S - \epsilon_i^h$ where ϵ_i^S is the elasticity of housing supply defined in text and ϵ_i^h is the elasticity of housing per resident.

Assumption 2. *All jurisdictions have the same housing price elasticity* $\left(\eta_j^h = \eta_k^h,\ \forall\, j,\, k\right)$.

Then it follows from (C.3) that

$$\widehat{p}^{-i}_{\tau_i}\overline{h}_{-i} = -\frac{n_i}{n_{-i}}\widehat{p}^{i}_{\tau_i}h_i. \tag{C.4}$$

where $n_{-i} = \sum_{j\neq i} n_j$, the sum of the populations other than jurisdiction i, $\overline{h}_{-i}$ is the average housing per capita in jurisdictions other than i, and the term $\widehat{p}^{-i}_{\tau_i} = \widehat{p}^{j}_{\tau_i}\,\forall j \neq i$. That is, we have the same percentage change in housing price in all jurisdictions other than i with the change in price of opposite sign of $\widehat{p}^{i}_{\tau_i}$ and of magnitude inversely related to the relative populations of jurisdiction i and all other jurisdictions.

Assumption 3. *There are no spillover effects* $\left(DE^{j}_{\tau_i} = 0, \forall j \neq i\right)$.

Then assuming τ_i only directly effects U^i from (C.1) we have

$$\frac{dU^i}{d\tau_i} = \frac{dU^j}{d\tau_i} \Rightarrow -\widehat{p}^{i}_{\tau_i}p_ih_i + DE^{i}_{\tau_i} = -\widehat{p}^{j}_{\tau_i}p_jh_j,\ \forall j \neq i \tag{C.5}$$

or

$$\widehat{p}^{j}_{\tau_i} = \frac{p_ih_i}{p_jh_j}\widehat{p}^{i}_{\tau_i} - \frac{1}{p_jh_j}DE^{i}_{\tau_i} \tag{C.6}$$

where we use Roy's identity $\left(\frac{\partial U_j}{\partial p_j}\frac{\partial p_j}{\partial \tau_i} = -h_j\frac{\partial p_j}{\partial \tau_i} = -p_jh_j\widehat{p}^{j}_{\tau_i}\right)$ to obtain (C.6). Using (C.3) with (C.6) gives

$$p_ih_i\ \widehat{p}^{i}_{\tau_i} = \frac{\sum_{-i} n_j\eta^h_j\phi^h_{ij}}{\sum n_j\eta^h_j\phi^h_{ij}}DE^{i}_{\tau_i} \text{ and } p_jh_j\ \widehat{p}^{i}_{\tau_i} = -\frac{n_i\eta^h_i\phi^h_{ij}}{\sum n_j\eta^h_j\phi^h_{ij}}DE^{i}_{\tau_i} \tag{C.7}$$

where $\phi_{ij} = \frac{p_ih_i}{p_jh_j}$.

If we now apply Assumption 2 with Assumption 3 Then it follows that we have

$$p_ih_i\widehat{p}^{i}_{\tau_i} = \left(1 - \frac{n_i}{N}\frac{\overline{ph}_{-i}}{p_ih_i}\right)DE^{i}_{\tau_i} \qquad \text{and} \qquad p_jh_j\widehat{p}^{i}_{\tau_i} = -\frac{n_i}{N}\frac{\overline{ph}_{-i}}{p_ih_i}DE^{i}_{\tau_i} \tag{C.8}$$

where $\overline{ph}_{-i}$ is the average property value in the jurisdictions other than i. When we assume that $p_ih_i = \overline{ph}_{-i}$, (C.8) simplifies to the equation in the text. Alternatively, we can obtain an estimate of $DE^{i}_{\tau_i}$ from the change in value of home in jurisdiction i as from rewriting the first expression in (C.8) we obtain

$$DE^i_{\tau_i} = \frac{p_i h_i \ \widehat{p}^i_{\tau_i}}{\left(1 - \frac{n_{-i}}{N} \frac{\overline{ph}_{-i}}{p_i h_i}\right)} \tag{C.9}$$

which reduces to the equation in the text.

Equation (C.8) has an elegant interpretation If jurisdictions are a small share of the metropolitan population, then the price change in the enacting jurisdiction is the direct effect in the WTP of residents (DE), that is, they are fully capitalized into prices. If jurisdiction have a significant share of the metropolitan population, then housing prices underestimates the impact on utility, as prices changes elsewhere. Thus, capitalization is incomplete and needs to be scaled by the relative population share of the other jurisdictions in the metropolis. Equation (27) simply states that once price changes in the enacting jurisdiction are estimated, researchers can use this estimate—appropriately scaled—to estimate the price changes, and thus, the WTP by residents.

Appendix D

Quantification of the Framework for Analyzing Local Policies

This appendix describes how our general framework developed in Section 2 can be calibrated to analyzing, in particular, education spending and property taxation and the resulting MVPF formulas. In addition, Supplementary Material S.D describes how our general but abstract framework developed in Section 2 can be operatinalized so the data and elasticies described in the present appendix are sufficient to calculate realistic MVPFs and MCTs.

D.1. The Metropolitan Statistical Area

As the causal wage effects we will estimate for education reforms will draw on school finance reforms over the last four decades, we calibrate our economy so it represents a typical 1990 U.S. metro area as reported in Table D.1. In our baseline specification, jurisdiction i which conducts the policy represents the central city of the MSA, though we will consider reforms in smaller jurisdictions in the MSA as robustness exercises. According to the 1990 U.S. Census, the median population of all MSAs was $240,635$ inhabitants. As there were approximately 2.7 individuals per households in the U.S., the our representative MSA includes $89,124$ households. In our baseline calibration, we assume that the largest city represents 17.38% of the population of the MSA.[5] Thus, $15,490$ households live in city i while the rest of the MSA (j) has a population of $73,634$ households. Notice that given the population share of city i, the total population of the MSA, does not affect the levels of the MVPFs and MCTs because all the terms in the numerator and denominator of the MVPFs are multiplied by either the population of i or that of j.

From the Census, there were 0.49 school age children per household in the U.S. Assuming that this number applies on average to the households of our MSA, we obtain that $43,627$ children live in i and $74,284$ live in other localities of the MSA. In the U.S. roughly 35% of households' gross income is spent on taxable consumption (Agrawal and Fox 2016). Yet, the household median income was \$$39,013$ (in 2000 dollars, given the causal wage estimates will be in those terms) according to the

5 This share corresponds to the population of Seattle in its MSA. We chose Seattle because data on landlord's ownership are available from Preis (2023) for this city. According to the U.S. Census, the median share of the central city was 37%. Seattle's share is thus relatively low; we provide robustess checks for various population shares in Section E.2.2.3.

Census, so that we calibrate the household taxable consumption to be \$13,655.

In our simplified model, we do not distinguish between renters and homeowners which means that we implicitly use an average of these two types of housing types. To do this, we compute the rental cost of housing as the average between the rent actually paid by a renter and the imputed rent of a homeowner. We obtain from the Census that in 1990 (in 2000 dollars), the annual median rent was \$6,540 and that the imputed rent of a median homeowner house was \$16,128.[6] As there were 65.2% of homeowners in the economy, we obtain that the weighted average of these two rental costs \$10,415 is as shown in Table D.1. Notice that we assume that this rental cost is identical in city i and in the rest of the MSA in our baseline specification, but we also explore robustness to price asymmetries between the jurisdiction enacting and not enacting the policy.. As discussed in the next subsection, this assumption is not innocuous as it implies that policies have no marginal effect on the aggregate housing rent/price in the MSA, i.e. $n_i \partial p_i^\kappa / \partial \tau_i + n_j \partial p_j^\kappa / \partial \tau_i = 0$, so that we also consider sensitivity the sensitivity of our results to heterogeneous housing rents/prices.

Table D.1. Calibration of the socio-economic features and direct spillovers, 1990 (values in 2000 dollars).

		City i	Other MSA j	Source
Number of households in k	n_k	15,490	73,634	1990 Census
Number of children in k	n_k^c	7,590	36,081	1990 Census
Annual taxable consumption of a resident of k	x_k	\$13,655	\$13,655	1990 Census
Annual median rent of housing in k	p_k^r	\$6,540	\$6,540	Poterba (1992)
Median value of a homeowner's house in k	ρ_k^o	\$115,195	\$115,195	Poterba (1992)
Share of rental properties in k owned by landlords living in				
city i	θ_{ik}^h	60.62%	4.52%	Preis (2023)
the rest of the MSA j	θ_{jk}^h	26.03%	82.13%	Preis (2023)
the state but out of the MSA	θ_{sk}^h	3.15%	3.15%	Preis (2023)
the federation but out of the state	θ_{Fk}^h	10.2%	10.2%	Preis (2023)

NOTE— For robustness checks, in some particular places explicitly mentioned, we alternatively use the 25^{th} percentiles of the house rents/values, $p_k^r = \$4,404$ and $\rho_k^o = \$72,088$, or the 75^{th} percentiles, $p_k^r = \$9,204$ and $\rho_k^o = \$200,682$.

With respect to landlord residential locations, we use data from Preis (2023). Preis uses rental registries, rather than tax assessment databases, to identify rental properties/landlords. Only a subset of cities have rental registries, but these data allow him to calculate the share of landlords who live in the city he owns property in, live in the same MSA as he owns property in and live in the same (or out of state) from where he owns property. He collects these data for several cities,

6 This imputed rent is obtained as follows. The median annual gross price of a homeowner house was \$115,195. This price includes the property tax whose rate was 2.5% on average applied to the assessed value of the house which represented 52.5% of its price (Twait 2011). Thus, the net of tax price of a homeowner house was of $115,195/(1+0.025 \times 0.525) = 113,703$ dollars. Poterba (1992) finds that this market price needs to be multiplied by 0.141845 to be converted into an imputed rent, which gives \$16,128.

and given they illustrate a very similar pattern across cities, we calibrate our shares so that they are identical to those of Seattle: 60% of the properties in city i are owned locally, 26.03% are owned by landlords living in other localities of the MSA, 3.15% are owned by households residing in the state of city i but outside the MSA, and 10.2% are supplied by landlords other places in the federation. We assume that the same shares apply to each other locality in the composite jurisdiction j. This implies that $\theta^h_{jj} = 60.62\% + \frac{n_j}{n_i+n_j} \times 26.03\% = 60.62\% + 21.50\% = 82.13\%$ of housing is owned in j. The extra 21.50% come from the fact that we assume that for each jurisdiction in j, the 26.03% owned from other places in the places are evenly distributed among households living in and j and the residents of city i who own $\theta^h_{ij} = \frac{n_i}{n_i+n_j} \times 26.03\% = 4.52\%$ of the housing stock in j.

As we are interested in schooling expenditure in i, we need to know how many children will work in j as adult. However, data on these interjurisdictional spillovers are rare. But recall that i is the central city of the MSA which certainly benefits from strong attractiveness and agglomeration economies. Hence, it is likely that only few children educated in the big city i work in more suburban areas of the MSA as adult. Thus, for simplicity, we assume that all children educated in i work in i as adult, i.e. $n^c_{ii} = n^c_i$ and $n^c_{ij} = 0$.[7] But, given local sales taxes and any consumption responses are small, this assumption is innocuous; alternatively, we could have simply assumed localities do not have a local sales tax rate (which many do not in the U.S.).[8]

7 In the case of Austin in Texas, we obtained data on these spillovers from Simon (2021) that we use in Appendix E.1.

8 From section S.D.2, we see that the levels of n^c_{ii} and n^c_{ij} only affects the behavioral effects (S.D.15). In other words, by assuming that people work as adults where they studied as children, we ignore the sales tax revenues that other jurisdictions would collect from the higher earnings of those who benefited from schooling expenditures in i. However, as local sales tax rates are particularly low (Table D.2), the local behavioral effects are really small, so any value of $n^c_{ij} \in [0, n^c_i]$ would entail the roughly same local/social MVPFs and MCT.

Table D.2. Calibration of the policy instruments, 1990.

		Value	Source
A. Local schooling expenditure			
Education spending per student	g_k	\$4,800	Jackson, Johnson, and Persico (2016)
B. Local taxes			
Local property tax rate	t_k^h	1.1%	Poterba (1992) and Twait (2011)
Local sales tax rate	t_k^x	1.3%	Agrawal (2014)
C. State taxes			
State income tax rate on labor income	t_{S}^ℓ	2.6%	Hendren and Sprung-Keyser (2020)
State income tax rate on rental income	t_{S}^h	2.6%	Hendren and Sprung-Keyser (2020)
State sales tax rate	t_{S}^x	5.5%	Agrawal (2014)
D. Federal taxes			
Federal income tax rate on labor income	t_{F}^ℓ	16.2%	Hendren and Sprung-Keyser (2020)
Federal income tax rate on rental income	t_{F}^h	17.3%	Hendren and Sprung-Keyser (2020)

Note— The effective property tax rate, t_k^h, is the observed property tax rate on values times the assessment ratio.

Table D.2 reports the calibration of the local, state and federal policy instruments. Notice that the local property tax rate has been adjusted so it can directly be applied to our rent variable p_i. As well known, at the local level, the main tax is the property tax. At the state level, the tax rates suggest that revenues are collected more evenly from income and sales. At the federal level, household taxes are predominantly the income taxes.

D.2. Elasticities

As discussed in section S.D.3.2, four types of elasticites are required to assess the local/social MVPFs and the MCTs of local policies: (1) the housing price elasticity with respect to the policy, (2) the earning response to the policy, (3) the tax reaction function and (4) the price elasticity of the housing supply. Estimates of these elasticities are reported in Table D.3.

Table D.3. Calibration of the elasticities and policy responses, based on estimates in the literature.

		Coef.	Source
Elasticity of housing price w.r.t. educational spending	$\varepsilon_{p,g}$	0.943 (0.158)	Bayer, Blair, and Whaley (2020)
Elasticity of housing price w.r.t. property tax increase	ε_{p,t^h}	−0.165 (0.031)	Bayer, Blair, and Whaley (2020)
Earning gain from one extra dollar of education spending	$\partial w_i^c / \partial g_i$	5.297 (2.67)	Jackson, Johnson, and Persico (2016), Hendren and Sprung-Keys
Slope of the property tax reaction function	$\partial t_j^h / \partial t_i^h$	0.300 (0.096)	Brueckner and Saavedra (2001)
Price elasticity of the housing supply	$\varepsilon_{H,p}$	0.350 (0.120)	Baum-Snow and Han (2024)

Note— Standard errors are reported in parenthesis.

The house price and public expenditure per student are calibrated according to Bayer, Blair, and Whaley (2020). We use their estimates for the elasticity of housing price with respect to educational spending, $\varepsilon_{p,g} = 0.943$ (se: 0.158). However, their elasticity of the housing price is with respect to the property tax revenue paid per pupil of -0.197 (se: 0.0449). As the model is the elasticity with respect to the tax rate, we adjust their elasticity with respect to be a rate elasticity. Thus, as the property tax pupil increases by one percent, the housing price decreases by $\varepsilon_{p,r^h} = -0.197 \times 1,795/3,884 = -0.091$ (se: 0.021) percent. Then, $\varepsilon_{p,t^h} = -0.091/(1+0.091) = -0.0834$ and using the delta method, the standard error is 0.0174, as stated in Table D.3.[9]

The children's future earning gain, $\partial w_i^c/\partial g_i$ is estimated from Jackson, Johnson, and Persico (2016) as previously utilized in Hendren and Sprung-Keyser (2020). They find a present discounted value of earnings increase of \$10.81 per student for every \$1 of upfront spending. As, we assume that there is 0.49 child per household so that \$1 spending increases the earnings by $10.81 \times 0.49 = 5.297$ dollar per household. Finally, we use the slope of the property tax reaction (Brueckner and Saavedra 2001) function and the housing supply elasticity (Baum-Snow and Han 2024).

9 Proof. The elasticity, $\varepsilon_{p,r^h} = (\partial p_i/\partial r_i^h) \times (r_i^h/p_i)$, is transformed into the elasticity of the housing price with respect to the property tax rate, $\varepsilon_{p,t^h} = (\partial p_i/\partial t_i^h) \times (t_i^h/p_i)$, as follows:

$$\varepsilon_{p,r^h} = \frac{\left(\frac{t_i^h p_i n_i}{\phi n_i}\right)}{p_i} \frac{\mathrm{d}p_i}{\mathrm{d}\left(\frac{t_i^h p_i n_i}{\phi n_i}\right)} \iff \varepsilon_{p,r^h}^i = t_i^h \frac{\mathrm{d}p_i}{\mathrm{d}\left(t_i^h p_i\right)} \iff \varepsilon_{p,r^h} = \frac{\varepsilon_{p,t^h}}{1+\varepsilon_{p,t^h}} \iff \varepsilon_{p,t^h} = \frac{\varepsilon_{p,r^h}}{1-\varepsilon_{p,r^h}},$$

recalling that the number of student per household is an exogenous demographic parameter ($\phi = n_i^c/n_i = 0.49$).

Appendix E
Empirical Appendix

This appendix includes information related to the empirical applications. Appendix E.1 deals with the higher education example. Appendix D already described the quantitative framework used to analyze the K-12 and property tax applications while Appendix E.2 completes the K-12 education example. Appendix E.3 supplements the application to a property tax cut. Appendix E.4 supplements wealth taxation application. Appendix E.5 provides details about estimating the MVPFs for the example of bidding for firms. Appendix E.6 supplements the flood protection application.

E.1. Higher Education Scholarship Programs

We are interested in the welfare effects of a cut in tuition fees, a common policy tool in higher education. Following Denning (2017), Hendren and Sprung-Keyser (2020) and Simon (2021), we consider the following experiment: school districts are annexed to Austin Community College district and receive in-district tuition rates.

E.1.1. Texas Community Colleges

In the state of Texas, community college tuition depends on the household residence. In-district students receive lower tuition rates than out-of-district students. Communities be annexed into the community college district, receiving lower tuition in exchange for being subject to the community college tax base. We focus on the policy as the tuition cut.

For purposes of this policy experiment, there are potentially many different "local" governments. We could, for example, define the "local" governments to be either the existing towns in the community college district or alternatively, the towns annexed into the district. In this section, we consider the annexed districts as the local government corresponding to our LMVPF, and thus, we think of the policy as their agreement to join the district. We do this because the causal wage gains from additional educational attainment induced by the policy in Denning (2017) accrue to the individuals in the annexed areas. This choice allows us to build on the wage gain estimates of willingness to pay—rather than inferring valuation entirely from house price changes.

In addition, there are many possible annexations we could consider over the time period. Simon (2021) uses a structural model to estimate the capitalization effects of annexation at the town level. We focus on the scenario where he calculate the optimal size of the community college. We use this specification of a hypothetical annexation that he proposes, rather than a single district annexation, it allows us to use estimates from both his reduced form models and his structural model. Figure E.1 shows the thought experiment that we consider, delineating the existing areas in the district, the annexed areas, and areas in the MSA that are not annexed into the community college area. As a result, the annexation will have spillovers on existing areas and areas not annexed into the district, as well as possibly for the state of Texas and the United States more generally.

The MSA includes 39 school districts, as represented in Figure E.1. Among them, 9 districts are initially in Austin Community College, 16 districts are annexed and 14 districts are neither remain outside the Austin Community College area (Simon 2021).

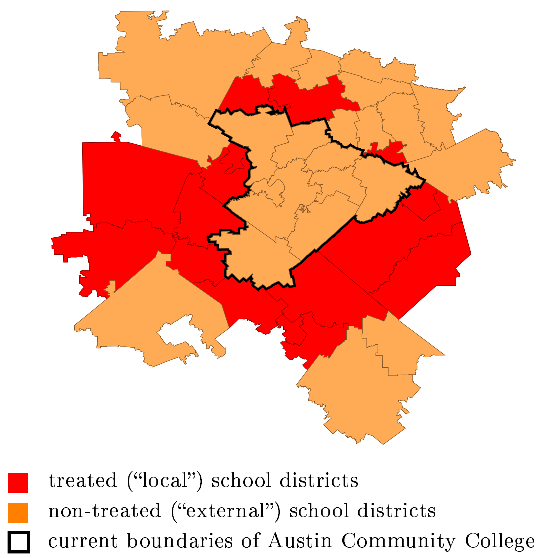


Figure E.1. Texas Community Colleges Policy Experiment. The figure represents the local school districts in the Austin MSA. It shows the policy experiment that we consider. “Local” jurisdictions are the annexed areas which benefit from a cut in tuition fee. “External” jurisdictions are those school districts in the MSA that are already in Austin Community College or those in the metro area that are not annexed.

Table E.1 reports descriptive statistics for the 16 annexed school districts for which we will compute the local MVPF, and for the 23 other school districts of the MSA which are included in the computation of the social MVPF. One can see that the treated districts (8,398 inhabitants, on average) are less populated than the non-treated ones (28,949 inhabitants, on average). This implies that aggregate external effects in the social MVPFs will be large. However, there is one element of caution regarding this table. For space constraints, we pool the existing areas in the taxing districts and the communities inside the MSA that remain outside the district after annexation. Obviously, the price changes in these two areas could be very different, along with the observation that areas in the existing district are much likely to be larger.

Table E.1. Treated ("local") and non-treated ("external") school districts in the MSA of Austin (Simon 2021).

		Treated ("local") districts					Non-treated ("external") districts				
		Mean	SD	Min	Max	Obs	Mean	SD	Min	Max	Obs
Nb. of households	n_i	8,398.4	9,211.8	281	28,891	16	28,948.5	60,670.4	735	285,356	23
Property tax rate (%)	t_i^h	15.19	1.7	12.02	17.67	16	16.22	1.81	13.35	18.88	23
Nb. of students enrolled prior to the program	n_i^S	253.8	582.6	6	2,375	16	583.2	1,355.5	9	6,491	23
Nb. of students enrolled due to the program	$\mathrm{d}n_i^S$	125.9	289.5	3	1,180	16	0	0	0	0	23
→ stay in the MSA of Austin	$\mathrm{d}n_{i,\mathrm{A}}^S$	13.19	30.41	0	124	16	0	0	0	0	23
→ stay in Texas out of the MSA of Austin	$\mathrm{d}n_{i,\mathrm{TX}\notin A}^S$	85.94	197.5	2	805	16	0	0	0	0	23
→ leave outside of Texas	$\mathrm{d}n_{i,\mathrm{S}\notin\mathrm{TX}}^S$	26.88	61.54	1	251	16	0	0	0	0	23
Nb. of renter households	n_i^r	2,555.5	4,428.8	69	17,688	16	12,082.7	32,754.	146	156,786	23
Nb. of homeowner households	n_i^o	5,842.9	5,994.2	212	21,947	16	16,865.8	28,703.2	564	128,570	23
Change in housing rent ($)	$\mathrm{d}p_i^r$	216.4	124.3	−9	503	16	−20.17	10.84	−40	−3	23
Change in homeowner house value ($)	$\mathrm{d}p_i^o$	796.4	667.7	−37	2,793	16	−68.3	57.36	−288	−8	23

NOTE— Following the same approach as in Appendix D, all house prices are converted to rents using Poterba (1992), and the reported property tax rates are adjusted to directly apply to rents using Poterba (1992) and Twait (2011). The non-treated regions pool communities already in the school districts as well as ones that stay outside of the district; these two sets of communities are quite heterogeneous and may have different price responses.

Quantifying the MVPFs and MCTs requires to calibrate or estimate several terms as reported in Table E.2. The same local (i.e. district-level), state and federal taxes as in our quantitative model (Appendix D) are relevant for the analysis of higher education expenditure policies, except that the values they are calibrated to may differ (for example, in Texas, the state income tax is zero). In addition to their local property tax (Table E.1), the districts also tax sales. The state of Texas only taxes sales, but it does not tax income. Other states levy tax from sales taxes and from labor income. As we assume that all properties in the MSA of Austin are owned by residents of the MSA which is fully embedded in Texas, the others' state rental income tax do not play any role here. Of course, the federal government does not tax sales but it taxes labor income and rental income.
Table E.1 also shows that the program considerably increased the number of students enrolled, by on average 68 more enrolled students per district. Among them, only 7 stay and work in the MSA of Austin as adults, 46 in other places of Texas, and 14 work outside of Texas. This significant mobility will be accounted for in the calculation of our MVPFs below.

Table E.2. Calibration: Austin Community College.

Description	Variable	Value	Source
A. Tax rates			
Local sales tax	t_i^x	2.%	Agrawal (2014)
State and local sales tax rate, out of Austin, in Texas	$t^x_{\text{TX}\notin A}$	7.85%	Agrawal (2014)
Texas state sales tax rate	t^x_{TX}	6.25%	Agrawal (2014)
Other states' sales tax rate paid (includes local rate)	$t^x_{\text{S}\notin\text{TX}}$	7.11%	Agrawal (2014)
Other states' income tax rate on labor income	$t^\ell_{\text{S}\notin\text{TX}}$	4.33%	
Federal income tax rate on labor income	t^ℓ_{F}	21.8%	Hendren and Sprung-Keyser (2020)
Federal income tax rate on rental property income	t^h_{F}	17.3%	Hendren and Sprung-Keyser (2020)
B. Program-related parameters			
Earning gain for a beneficiary student ($)	$\mathrm{d}w$	8,857	Hendren and Sprung-Keyser (2020)
Extra taxable consumption of a beneficiary student ($)	$\mathrm{d}x$	3,100	Agrawal (2014)
Individual contritbution to tuition ($)	f	407	Hendren and Sprung-Keyser (2020)
Tuition change for any student in a treated district ($)	$\mathrm{d}\tau$	1,542	Simon (2021)
Cost of increased attainment for a beneficiary student ($)	c	4,160	Austin Communty College

NOTE— Following the same approach as in Appendix D, the additional taxable consumption $\mathrm{d}x$ is computed by assuming that it represents 35% of the earning gain $\mathrm{d}w$.

E.1.2. Local MVPF, Social MVPF and MCT

This higher education application differs from the other empirical applications because it is an actual reform that allows us to exploit a rich district-level dataset of observed variables (tuition fees, house prices, earnings, etc.). Our general model developed in Section 2 makes it particularly easy to incorporate all the observed heterogeneity in the data to compute realistic local MVPFs, social MVPFs and MCTs of this reform. More generally, this empirical application shows how our framework can easily be taken to real datasets incorporating a lot of heterogeneity. Hereafter, we investigate the effects of a dollar cut in the tuition fee. The formal details of how our model is taken to the data are provided in Supplementary Material S.D.4. Below, we report the resulting quantitative results.

E.1.3. Local MVPF

The local MVPF of the treated districts from an overall \$1 cut in tuition fee is $LMVPF = \sum_{i\in\mathcal{L}}(\mathrm{DE}^i + \mathrm{IE}^i + \mathrm{OE}^i)/\sum_{i\in\mathcal{L}}(\mathrm{ME}^i + \mathrm{BE}^i + \mathrm{PE}^i)$ in which the numerator is the sum of the willingness to pay of the treated districts $i \in \mathcal{L}$ and the denominator is the sum of their net government costs. The different effects are described below.

Local Marginal Willingness to Pay. The local marginal WTP includes the direct effect on each treated school district which includes two direct benefits. The first is the direct expenditure of the program equal to the \$1 saving in tuition fees for the students living in the treated district already involved in college. The second benefit is the \$2.72 the wage gain for the marginal students involved in college because of the program. The local disposable income effect is the \$1.371 reduction in the renters' disposable income effect due to the increase in the rent resulting from the greater attractiveness of the treated districts. The ownership effect in district is $-\$0.949$ which reflects the fact that as the price of their property increase, homeowners have to pay more property tax. In sum, the local marginal willingness to pay of the annexed districts for the cut in tuition fee is $LWTP = \$1.399$.

Local Marginal Net Government Cost. The local marginal NGC includes the mechanical effect which has two sub-effects. The first is the \$1 direct expenditure due to cutting the tuition fees. The second is the \$1.339 direct costs due to increased educational attainment, including both the direct costs of the program and the added costs of community college educating another student.

The behavioral effect is the \$0.0021 extra local sales tax revenue generated by the program, because the additional students enrolled in college earn higher wages in the future, and thus consume more taxable goods. This effect is negligible because the local jurisdictions only levy a small tax rate, tax a small amount of consumption, and because many individuals educated in the community college district leave the jurisdiction. In particular, this effect as well as other tax effects, are prorated by the number of individuals who stay in the jurisdiction after graduation. To do this, we use Conzelmann, Hemelt, Hershbein, Martin, Simon, and Stange (2021) who estimate transition matrices after graduation. These authors estimate that only 10.5% of Austin Community College grads stay in the Austin area. For purpose of this calculation, we assume all individuals induced to takeup the program from the annexed districts who stay in Austin do so by returning to their home distinct. As a result, prorating by 10.5% means we likely overestimate this effect as some of them likely stay in the metro area but move to Austin. These authors also estimate that 68.2% of grads stay in Texas, but move outside the Austin area, while the remainder leave the state. The price effect in the treated district i is the \$1.715 additional property tax revenues collected from the capitalization of the housing prices of both rental properties and homeowners' ones. Summing all these effects, we obtain $LNGC = \$0.622$ and thus $LMVPF = 2.249$.

E.1.4. Social MVPF and MCT

We consider the social MVPF of the state government of Texas which is $SMVPF^{\text{TX}} = (LWTP + EWTP^{\text{TX}})/(LNGC + ENGC^{\text{TX}})$, and that of the federal government which is $SMVPF^{\text{F}} = (LWTP + EWTP^{\text{F}})/(LNGC + ENGC^{\text{F}})$.

External Marginal Willingness to Pay. The external marginal willingness to pay is the sum of the marginal WTP of all the residents living in non-treated areas in Texas and of those living elsewhere in the federation. The disposable-income and ownership effects in the non-treated districts of the MSA are respectively \$1.132 and \$0.532. Some properties of the MSA are also owned by landlords living elsewhere in Texas who also benefit from an ownership effect \$0.005. Similarly, landlords living elsewhere in the federation benefit from an ownership effect of \$0.0165. In sum, $EWTP^{\text{TX}} = \$1.67$ and $EWTP^{\text{F}} = \$1.69$.

External Marginal Net Government Cost. The external marginal net government costs of Texas and of the federal government include the price effect on property tax revenues of the non-treated district j of the MSA, and the vertical fiscal externality of the program on the state of Texas.In addition to ENGC of Texas, the ENGC of the federal government includes its own vertical fiscal externality on federal income tax revenues from higher wages. In addition, we assume higher level governments care about local governments, so this terms also includes fiscal effects in other states, including income tax changes from newly induced college students moving there as well as added sales tax revenue from those movers. As mentioned above, 21.3% of Austin Community College grads who were induced into the program likely leave the state.

The first component of the marginal NGC of Texas is a \$1.12 cost incurred by the non-treated districts due to the house price cuts on their property tax revenues. The capitalization effects in *each* district is obtained from Simon's model. These price changes, like those in the annexed areas, are district specific. In other words, this aggregation accounts for the fact that price changes might be, for example, large in nearby jurisdictions compared to those further away.

In addition to the external marginal NGC of the districts of the MSA, the program allows the state of Texas to collect sales tax revenues which result from beneficiary students moving outside of the Austin area, consuming more, and paying local and state sale taxes. Of course, those individuals who stay in the metro area also pay sales taxes. We compute that this behavioral effect amounts to $-\$0.06$, so that the external marginal NGC of the state of Texas is $ENGC^{\text{TX}} = 1.06$, the social MVPF of the Texas is $SMVPF^{\text{TX}} = 1.82$, its MCT is -22.7%, and its match rate is -0.185.

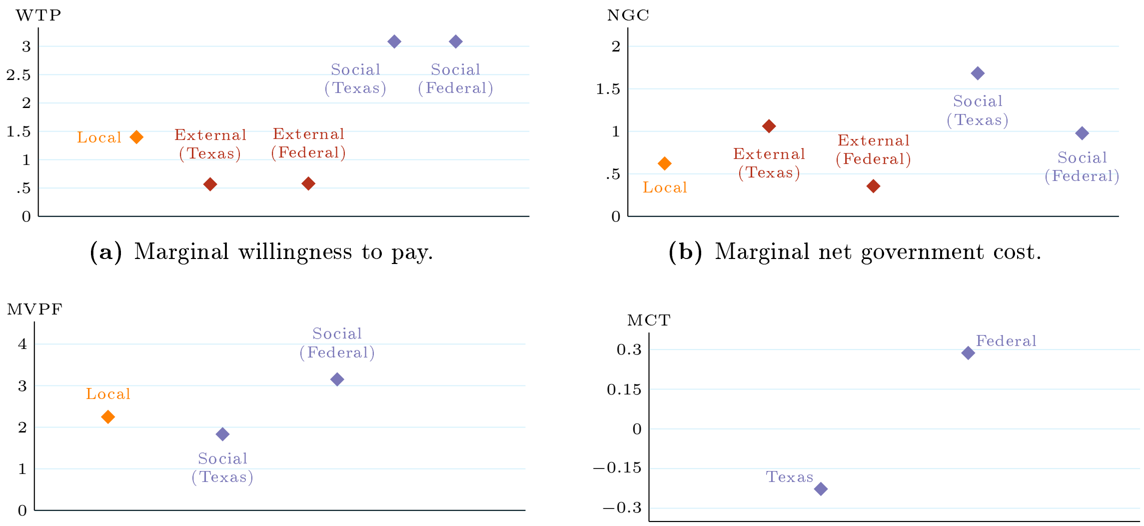
Let us now turn to the federal government. The federal vertical fiscal externality of the program includes the same behavioral effects from added sales tax revenue in states other than Texas, resulting from people induced to go to college moving there. We measure a small behavioral effect of $-\$0.015$, because only few students leave Texas as seen in Table E.1.

Unlike Texas, other states levy income taxes, so that they will be able to tax the earning increase of the students who benefited from the program and will locate there as workers. This gives rise to a $-\$0.026$ price effect. Similarly, the federal government also taxes these additional labor earnings. However, in addition, it will collect tax revenues from its income tax t_{F}^{h} on rental income even if those landlords live in Texas. This entails a price effect of $\text{PE}^{\text{F}} = -\$0.66$. The external marginal NGC of the federal government is $ENGC^{\text{F}} = 0.356$, its social NGC is $SNGC^{\text{F}} = 0.978$. The social MVPF of the federation is $SMVPF^{\text{F}} = 3.15$, its MCT is 28.66% and its match rate is 0.4018.

The MCT of the federal government is higher than that of the state, showing how the availability of taxing instruments influences the MCT. Because Texas does not levy an state income tax, thus being unable to benefit from the large wage gains of marginal individuals, the state of Texas has less incentive to subsidize higher education than the federal government which levies an income tax. The above results appendix are summarized in Table E.3 and Figure E.2 which does not include confidence intervals because they are not available from the structural model of Simon (2021).

Table E.3. Higher education spending: LMVPF, SMVPF, MCT and match rate.

		Local	External			Social	
			cities	Texas	fed	Texas	fed
Willingness to pay							
Direct benefits	DE	3.72				3.72	3.72
Rental cost of housing	IE	−1.371	1.132			−0.24	−0.24
Housing ownership income	OE	−0.949	0.532	0.005	0.016	−0.412	−0.396
	Total	1.399	1.685	0.005	0.016	3.068	3.084
Net government cost							
Mechanical expenditure	ME	2.339				2.339	2.339
Sales tax revenue	BE	−0.002		−0.06	−0.015	−0.062	−0.077
Property tax revenue	PE	−1.715	1.121			−0.594	−0.594
Net cost of new residents	LE	0	0			0	0
State and Federal income tax revenue	VE				−0.689		−0.689
	Total	0.622	1.121	−0.06	−0.704	1.683	0.978
Marginal value of public funds	MVPF	2.249				1.833	3.152
Marginal corrective transfer	MCT					−0.227	0.287
Match rate	M					−0.185	0.402



(a) Marginal willingness to pay.

(b) Marginal net government cost.

(c) Marginal value of public funds.

(d) Marginal corrective transfer.

Figure E.2. MVPFs and MCT of a higher education scholarship program.

E.2. K-12 Education Spending

E.2.1. Background on the Effects of K-12 Education Spending

One approach to measuring the WTP of K-12 education is to treat the effect of school spending or educational reforms on the future earnings as the benefit relying on evidence from studies such as Jackson, Johnson, and Persico (2016). An alternative, that we follow here, follows a literature on how educational spending is capitalized into property values. While our example uses evidence from Bayer, Blair, and Whaley (2020), that the benefit of educational spending can be determined from how it affects property values while the costs of these spending increases are found from the effect of balanced-budget increases in property taxes has been the premise for studies since Oates (1969). Rosen (1974) provides the formalization of how these hedonic estimates can be used to obtain benefits and costs.

Bayer, Blair, and Whaley (2020) follows Brueckner (1979), Brueckner (1980), and Brueckner (1982) in developing a model of households choosing where to live, that is, in which school district based on the educational services, and the property tax rate. As households are mobile, in equilibrium, all households of the same income and tastes receive the same utility regardless of where they live with differences in public services and taxes reflected differences in housing prices. Marginal willingness to pay for educational expenditures is the coefficient on educational spending in the hedonic regression of property value on the property attributes including local services and amenities while the marginal cost of the spending is obtained using the coefficient on the property tax rate. Bayer, Blair, and Whaley (2020), again following Brueckner (1979), Brueckner (1980), and Brueckner (1982), tests for whether teacher salaries are at an efficient level by using the estimates from the hedonic to determining whether a balanced budget increase in teacher salaries increases, decreases, or does not change property values. The efficient level of spending would have no effect on property values – the marginal benefit of increased spending as measures by the increase in property values equals the marginal cost, measured by effect of a balanced-budget increase in the property tax.

Implicitly Bayer, Blair, and Whaley (2020) assume that only property values in the district enacting a change in educational spending are affected; property values elsewhere are unchanged. This is an assumption of either an inelastic supply of housing or atomistic districts. If household mobility, in response to changes in educational quality, is national or regional, the assumption of atomistic districts is reasonable. But if, as seems likely, most household mobility is restricted to other, similar districts within the same labor market (MSA), districts may serve as significant share of the population. For example, the Chicago school district includes 37% of the Chicago-Naperville-Evanston PMSA population and the Detroit school district has 38% of the Detroit-Dearborn-Livonia population.

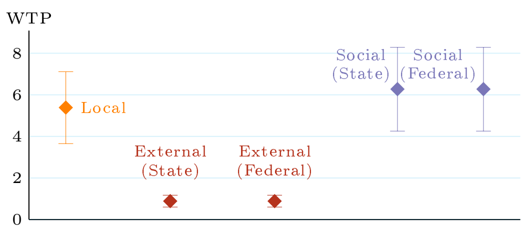
E.2.2. Results

E.2.2.1 Baseline Results

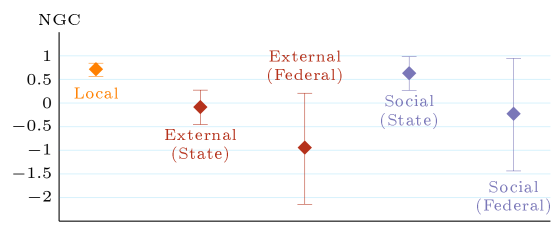
We consider, following Jackson, Johnson, and Persico (2016), a dollar increase, in perpetuity, in educational spending. The baseline results described in the main text are summarized in Table E.4 and Figure E.3. Then, Table E.5 and Table E.6 reports results for relatively low and high house prices in city i, as defined in the note of Table D.1. All of these results are derived using the framework in Appendix D.

Table E.4. K-12 education spending: LMVPF, SMVPF and MCT, with $p_i = p_j = p^{median}$.

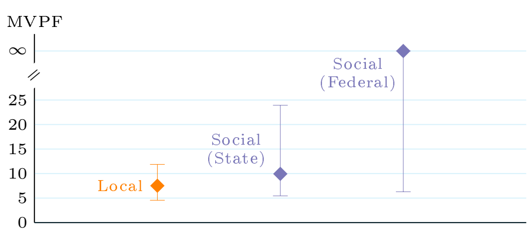
		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct utility benefit	DE	6.274				6.274	6.274
Rental cost of housing	IE	−0.912	0.912			0	0
Housing ownership income	OE	0.025	−0.025	0	0	0	0
	Total	5.387	0.887	0	0	6.274	6.274
Net government cost							
Mechanical expenditure	ME	1				1	1
Sales tax revenue	BE	−0.026	0.002	−0.207		−0.231	−0.231
Property tax revenue	PE	−0.417	0.417			0	0
Net cost of new residents	LE	0.159	−0.159	0	0	0	0
State and Federal income tax revenue	VE			−0.138	−0.858	−0.138	−0.996
	Total	0.716	0.26	−0.345	−0.858	0.631	−0.227
Marginal value of public funds	MVPF	7.523				9.939	∞
Marginal corrective transfer	MCT					0.243	1.272
Match rate	M					0.321	∞



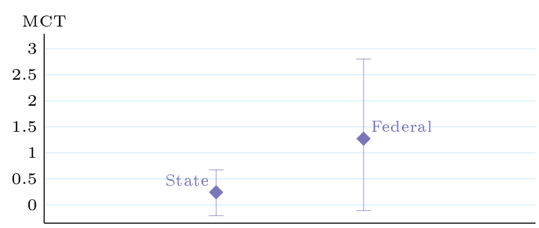
(a) Marginal willingness to pay.



(b) Marginal net government cost.



(c) Marginal value of public funds.



(d) Marginal corrective transfer.

Figure E.3. MVPFs and MCT of a K-12 education spending. Bars represent 95% confidence intervals using parametric bootstrap.

E.2.2.2 Heterogeneous house prices

Alternative housing price levels (Table D.1) are considered in the following tables.

Table E.5. K-12 education spending: LMVPF, SMVPF and MCT, with $p_i < p_j = p^{median}$.

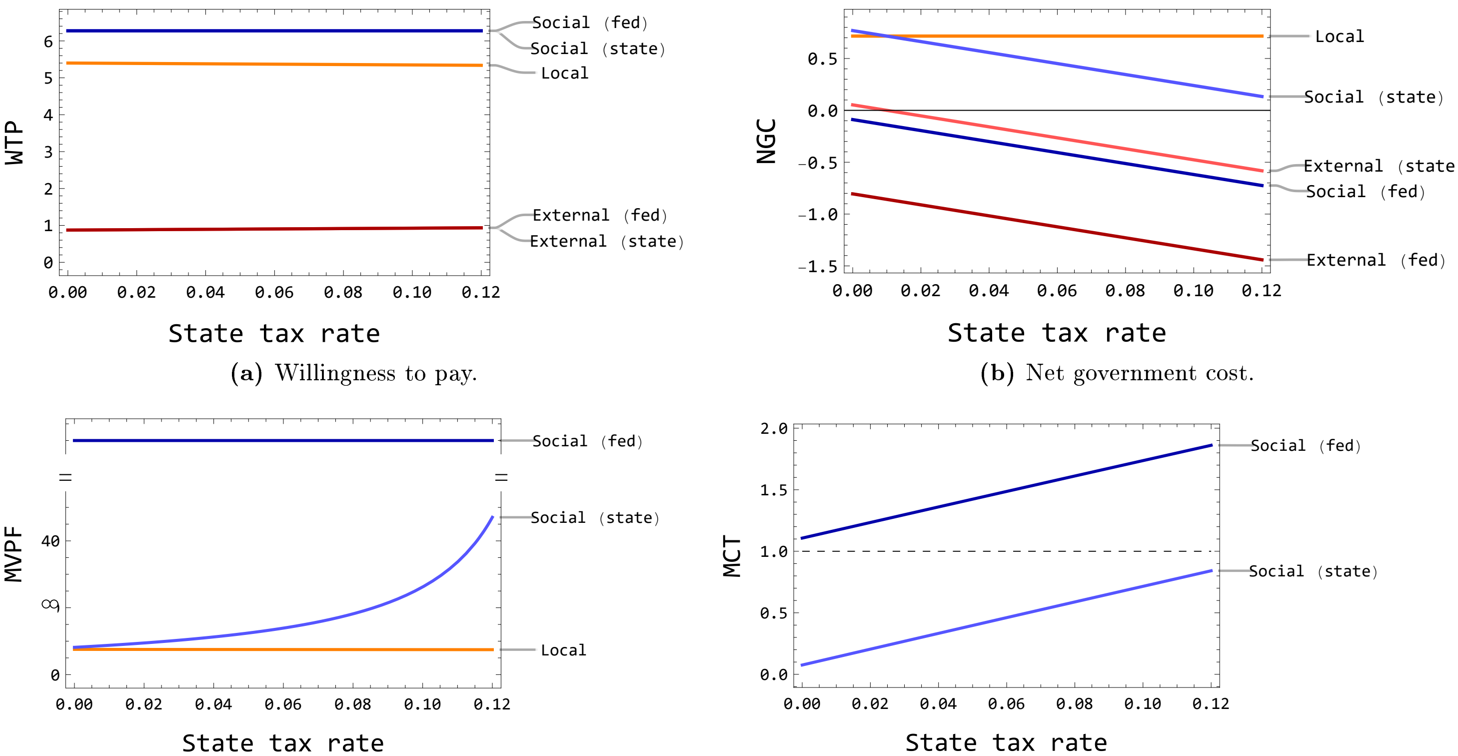
		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct utility benefit	DE	5.976				5.976	5.976
Rental cost of housing	IE	−0.614	0.912			0.298	0.298
Housing ownership income	OE	−0.105	−0.081	−0.007	−0.022	−0.193	−0.215
	Total	5.257	0.831	−0.007	−0.022	6.082	6.06
Net government cost							
Mechanical expenditure	ME	1				1	1
Sales tax revenue	BE	−0.026	0.003	−0.202		−0.225	−0.225
Property tax revenue	PE	−0.393	0.417			0.024	0.024
Net cost of new residents	LE	0.107	−0.159	−0.027	0.018	−0.08	−0.062
State and Federal income tax revenue	VE			−0.13	−0.807	−0.13	−0.937
	Total	0.688	0.26	−0.359	−0.788	0.589	−0.199
Marginal value of public funds	MVPF	7.637				10.321	∞
Marginal corrective transfer	MCT					0.26	1.251
Match rate	M					0.351	∞

Table E.6. K-12 education spending: LMVPF, SMVPF and MCT, with $p_i > p_j = p^{median}$.

		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct utility benefit	DE	6.646				6.646	6.646
Rental cost of housing	IE	−1.284	0.912			−0.372	−0.372
Housing ownership income	OE	0.188	0.044	0.008	0.027	0.241	0.268
	Total	5.55	0.957	0.008	0.027	6.515	6.542
Net government cost							
Mechanical expenditure	ME	1				1	1
Sales tax revenue	BE	−0.027	0.002	−0.213		−0.239	−0.239
Property tax revenue	PE	−0.447	0.417			−0.03	−0.03
Net cost of new residents	LE	0.076	−0.159	−0.039	−0.023	−0.122	−0.144
State and Federal income tax revenue	VE			−0.147	−0.922	−0.147	−1.07
	Total	0.602	0.259	−0.4	−0.945	0.462	−0.483
Marginal value of public funds	MVPF	9.213				14.096	∞
Marginal corrective transfer	MCT					0.346	1.68
Match rate	M					0.53	∞

E.2.2.3 Sensitivity graphs

This section illustrates how the baseline results in Table E.4 are altered by different levels of state income tax rate (Figure E.4), different population shares of the central city (Figure E.5) or different housing ownership assumptions (Figure E.6).



(a) Willingness to pay.

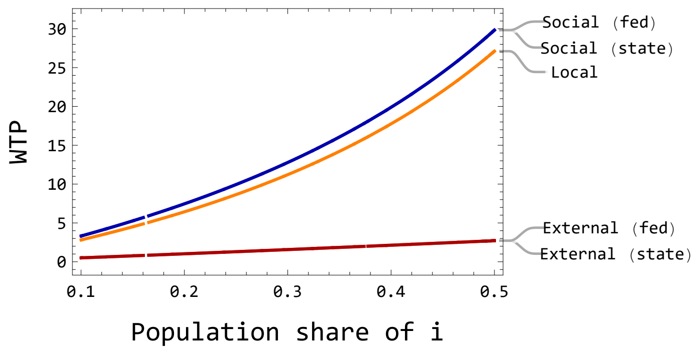
(b) Net government cost.

(c) Marginal value of public funds.

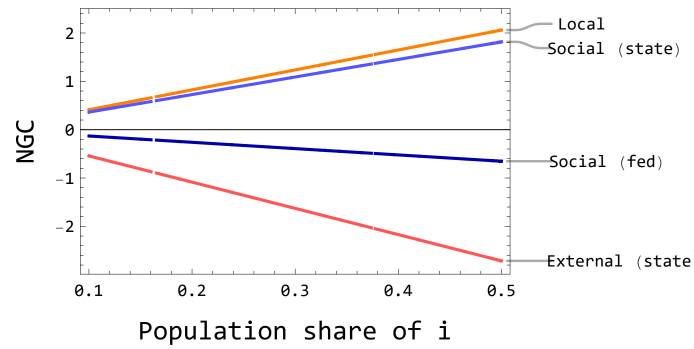
(d) Marginal corrective transfer.

Figure E.4. MVPF and MCT as a function of the income state tax rate.

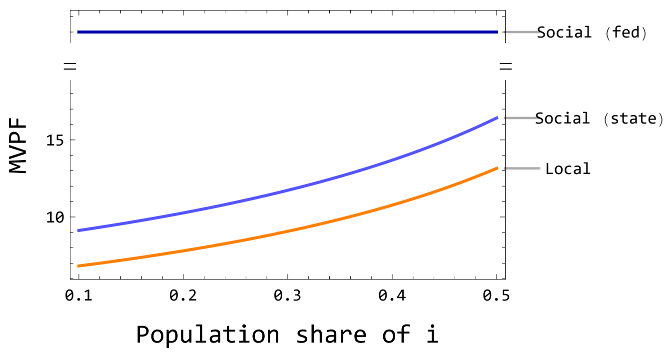
Figure E.6 considers different assumptions regarding the ownership of housing properties. One can observe that all baseline levels of MVPFs and MCTs are located in between the two extreme cases: fully local and fully external ownership. Another observation is that the location of the absentee owners does not matter, as long as they do not live in the MSA. This suggests that for welfare analysis, the simplification assumption of fully absentee owners often postulated in the literature may be a good approximation even for owners who do not reside in the MSA but who still live somewhere else in the economy.



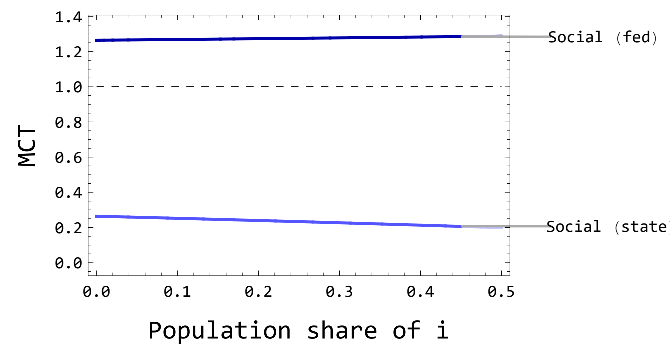
(a) Willingness to pay.



(b) Net government cost.



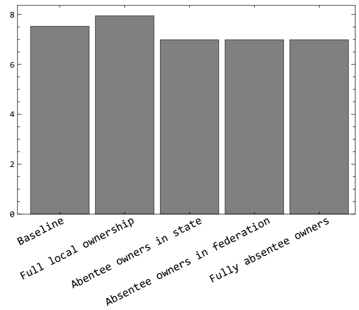
(c) Marginal value of public funds.



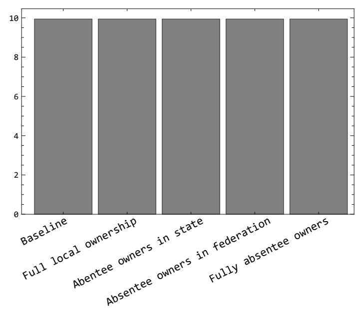
(d) Marginal corrective transfer.

Figure E.5. MVPF and MCT as a function of the population share of jurisdiction i.

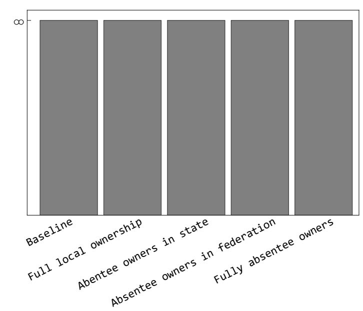
Specifically, the different ownership assumptions are defined as follows. First, "baseline" refers to the ownership shares, θ^h_{ij}, reported in Table D.1. Second, "full local ownership" assumes that all housing is owned in the jurisdiction where it is located, i.e. $\theta^h_{ii} = \theta^h_{jj} = 1$ and $\theta^h_{ij} = \theta^h_{ji} = \theta^h_{\mathrm{S}i} = \theta^h_{\mathrm{F}i} = 0$. Third, "absentee owners in state" assumes that all housing is owned by owners who do not live in the MSA but elsewhere in the state, i.e. $\theta^h_{\mathrm{S}i} = \theta^h_{\mathrm{S}j} = 1$ and $\theta^h_{ii} = \theta^h_{jj} = \theta^h_{ij} = \theta^h_{ji} = \theta^h_{\mathrm{F}i} = \theta^h_{\mathrm{F}j} = 0$. Fourth, "absentee owners in federation" assumes that all housing is owned by owners who do not live in the state but elsewhere in the federation, i.e. $\theta^h_{\mathrm{F}i} = \theta^h_{\mathrm{F}j} = 1$ and $\theta^h_{ii} = \theta^h_{jj} = \theta^h_{ij} = \theta^h_{ji} = \theta^h_{\mathrm{S}i} = \theta^h_{\mathrm{S}j} = 0$. Fifth, "fully absentee owners" means that all owners live outside the economy so that all ownership shares are equal to zero.



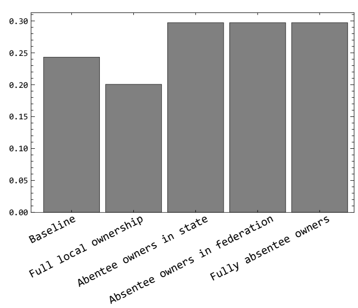
(a) Local MVPF.



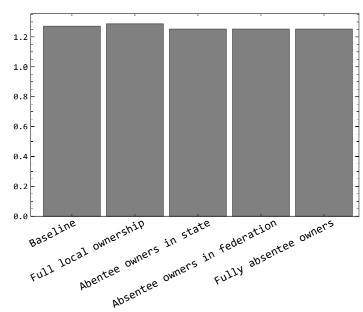
(b) Social MVPF of the state.



(c) Social MVPF of the federal government.



(d) MCT of the state.



(e) MCT of the federal government.

Figure E.6. MVPF and MCT with respect to different housing ownership assumptions.

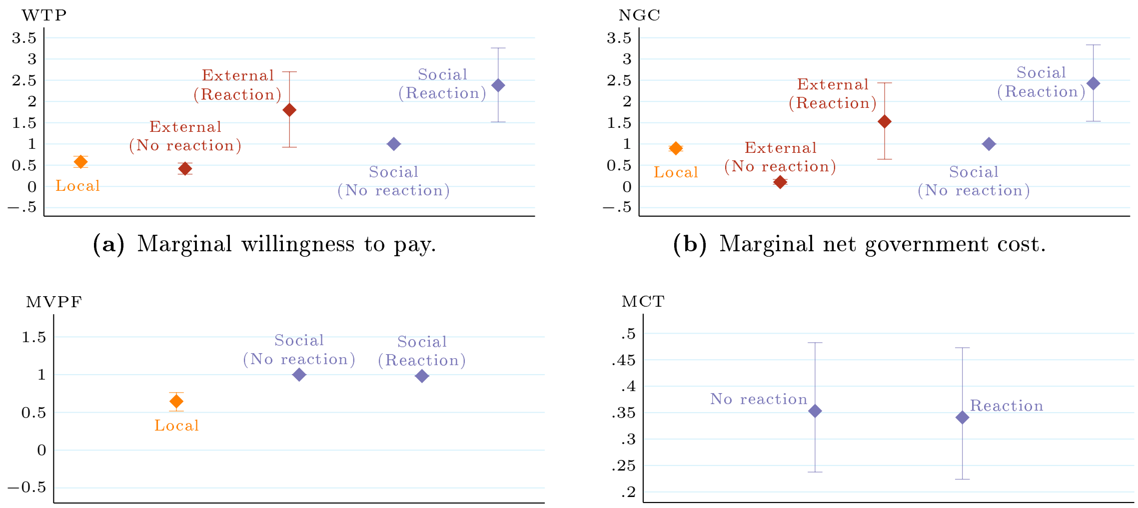
E.3. Property tax cut

Based on the model used for studying the effect of K-12 education spending Appendix D, this appendix investigates the effect of a one dollar cut in property tax revenue, $n_i p_i \mathrm{d}t_i^h = -1$. There are three differences compared to the K-12 case. First, unlike education spending, property tax cut does not affect the future earnings of the students. Therefore, given that the metropolitan wage is exogenous, there is no wage capitalization effect as can be seen in the local disposable income effect $\mathrm{IE}^i_{t_i^h}$. Second, contrary to the direct benefit of schooling which is challenging to estimate, the direct effect of a tax cut is directly observable from the data. So, we do not need the preference revelation approach used in the K-12 application to quantify $\text{DE}^i_{t_i^h}$. Third, the property tax cut generate strategic tax reactions in the non-treated jurisdictions.

The baseline results described in the main text are summarized in Table E.7 and Figure E.7.

Table E.7. Property tax cut: LMVPF, SMVPF, MCT and match rate, with $p_i = p_j = p^{median}$.

		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct income gain	DE	0.931	0.046	0.006	0.018	0.982	1
Income gain due to policy reaction	CDE		1.381			1.381	1.381
Rental cost of housing	IE	−0.36	0.36			0	0
Housing ownership income	OE	0.01	−0.01	0	0	0	0
No policy reaction	Total	0.58	0.396	0.006	0.018	0.982	1
Policy reaction	Total	0.58	1.783	0.006	0.018	2.363	2.381
Net government cost							
Mechanical expenditure	ME	1				1	1
Expenditure due to policy reaction	CME		1.426			1.426	1.426
Sales tax revenue	BE	−0.001	0.001	0		0	0
Property tax revenue	PE	−0.165	0.165			0	0
Net cost of new residents	LE	0.063	−0.063	0	0	0	0
State and Federal income tax revenue	VE			0	0	0	0
No policy reaction	Total	0.897	0.103	0.103	0.103	1	1
Policy reaction	Total	0.897	1.529	0	0	2.426	2.426
No policy reaction							
Marginal value of public funds	MVPF	0.647				0.982	1
Marginal corrective transfer	MCT					0.341	0.353
Match rate	M					0.518	0.546
Policy reaction							
Marginal value of public funds	MVPF	0.647				0.974	0.982
Marginal corrective transfer	MCT					0.336	0.341
Match rate	M					0.506	0.518



(a) Marginal willingness to pay.

(b) Marginal net government cost.

(c) Marginal value of public funds.

(d) Marginal corrective transfer.

Figure E.7. MVPFs and MCT of a property tax cut. The upper-government considered is the federal government. Bars represent 95% confidence intervals using parametric bootstrap.

Table E.8. Property tax cut: LMVPF, SMVPF, MCT and match rate, with $p_i < p_j = p^{median}$.

		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct income gain	DE	0.896	0.031	0.004	0.012	0.93	0.943
Income gain due to policy reaction	CDE		1.381			1.381	1.381
Rental cost of housing	IE	−0.243	0.36			0.118	0.118
Housing ownership income	OE	−0.041	−0.032	−0.003	−0.009	−0.076	−0.085
No policy reaction	Total	0.612	0.359	0.001	0.003	0.972	0.975
Policy reaction	Total	0.612	1.741	0.001	0.003	2.353	2.357
Net government cost							
Mechanical expenditure	ME	0.943				0.943	0.943
Expenditure due to policy reaction	CME		1.426			1.426	1.426
Sales tax revenue	BE	−0.001	0.001	0.002		0.002	0.002
Property tax revenue	PE	−0.155	0.165			0.009	0.009
Net cost of new residents	LE	0.042	−0.063	−0.011	0.007	−0.032	−0.024
State and Federal income tax revenue	VE			0.003	0.02	0.003	0.023
No policy reaction	Total	0.829	0.103	0.097	0.124	0.926	0.953
Policy reaction	Total	0.829	1.529	−0.006	0.027	2.352	2.38
No policy reaction							
Marginal value of public funds	MVPF	0.738				1.05	1.023
Marginal corrective transfer	MCT					0.297	0.279
Match rate	M					0.422	0.386
Policy reaction							
Marginal value of public funds	MVPF	0.738				1.001	0.99
Marginal corrective transfer	MCT					0.262	0.255
Match rate	M					0.356	0.342

Table E.9. Property tax cut: LMVPF, SMVPF, MCT and match rate, with $p_i > p_j = p^{median}$.

		Local	External			Social	
			cities	state	fed	state	fed
Willingness to pay							
Direct income gain	DE	0.974	0.064	0.008	0.025	1.046	1.072
Income gain due to policy reaction	CDE		1.381			1.381	1.381
Rental cost of housing	IE	−0.507	0.36			−0.147	−0.147
Housing ownership income	OE	0.074	0.017	0.003	0.011	0.095	0.106
No policy reaction	Total	0.541	0.442	0.011	0.036	0.995	1.031
Policy reaction	Total	0.541	1.835	0.011	0.036	2.376	2.412
Net government cost							
Mechanical expenditure	ME	1.072				1.072	1.072
Expenditure due to policy reaction	CME		1.426			1.426	1.426
Sales tax revenue	BE	−0.001	0.001	−0.002		−0.003	−0.003
Property tax revenue	PE	−0.176	0.165			−0.012	−0.012
Net cost of new residents	LE	0.03	−0.063	−0.015	−0.009	−0.048	−0.057
State and Federal income tax revenue	VE			−0.004	−0.025	−0.004	−0.029
No policy reaction	Total	0.924	0.102	0.081	0.046	1.005	0.971
Policy reaction	Total	0.924	1.529	−0.022	−0.034	2.431	2.397
No policy reaction							
Marginal value of public funds	MVPF	0.586				0.99	1.062
Marginal corrective transfer	MCT					0.408	0.448
Match rate	M					0.69	0.813
Policy reaction							
Marginal value of public funds	MVPF	0.586				0.977	1.006
Marginal corrective transfer	MCT					0.401	0.418
Match rate	M					0.669	0.718

E.4. Decentralized Wealth Taxation and Fraudulent Relocations

We consider treatment as Madrid's deviation to zero from the default schedule. We assume that each region obtains revenue from labor income taxes, capital income taxes, and wealth taxes. These three taxes represent over 90% of regional revenue. We consider the same five year horizon studied in Agrawal, Foremny, and Martínez-Toledano (2024). Acknowledging our model does not have a wealth tax, its MVPF would be similar to other household taxes.

E.4.1. MVPF calculation

This section provides details about the computation of the MVPFs. To obtain marginal effects, divide by the value of the tax cut in Madrid (€$47,457$) so that we consider a €1 tax cut.

E.4.1.1 Local MVPF

Letting the subeffects be denoted in Euros per initial wealth tax resident of Madrid, let us construct the local MVPF for the region of Madrid yields.

LWTP. The willingness to pay for the wealth tax decreases is equal to the taxes saved by Madrid adopting the zero tax rate instead of the default tax schedule. Using the wealth tax simulator from Agrawal, Foremny, and Martínez-Toledano (2024), we determine the tax liabilities of each pre-reform resident of Madrid who was eligible to pay wealth taxes. Calculating this in each year and aggregating the discounted values over five years, the local marginal WTP is €47,457 per resident (direct effect $\text{DE}^i_{\tau_i}$).

The absence of disposable and ownership effects is due to the fact that most residential relocations from other regions to Madrid were fraudulent (Agrawal, Foremny, and Martínez-Toledano 2024). To benefit from the tax cut, wealthy taxpayers who already owned housing in Madrid simply changed their primary residences there without actually moving. Thus, the local marginal WTP of a €1 cut is equal to €1 per resident.

LNGC. Given Madrid's tax rate is zero, $\text{ME}^i_{\tau_i}$ is also €47,457. The lower wealth tax rate results in savings behavioral response that increase taxable wealth via capital accumulation. However, because the wealth tax rate is zero, the added wealth tax base does not increase wealth tax revenues. Nor does it affect labor income taxes, as most wealth tax filers are rentiers. But the expansion of capital potentially translates into capital income tax revenues. To calculate the behavioral effect, we use the estimate (5.910, se: 0.813) of the elasticity of taxable wealth from Jakobsen, Jakobsen, Kleven, and Zucman (2020). We then calculate the amount of capital income taxes in the data due to expansion of capital in Madrid, assuming capital gains on that added wealth are realized proportionally over time. Because the elasticity of taxable wealth is relatively small and most capital gains are not realized, this results in €1,154 of added capital income tax revenue per resident (behavioral effect $\text{BE}^i_{\tau_i}$).

The locational effect has revenue consequences. Because the wealth tax rate is zero, movers to Madrid contribute no wealth tax revenue. But, because labor and capital income taxes are also sourced to the same region, Madrid realizes a tax revenue gain. To calculate the magnitude of the effect we use the causal estimates that show the cumulative increase in Madrid's stock of high-wealth individuals increased 1.5% one year later, 3.2%, 6.4%, 7.9% and 8.5% by five years later. Then, using these causal effects and the baseline number of residents in Madrid prior to decentralization, we calculate the cumulative amount of new residents in Madrid each year. To obtain the added amount of capital and labor income tax revenue, we multiply this number by the average income taxes of movers to Madrid.[10] This yields €1,611 more revenue per initial resident ($\text{LE}^i_{\tau_i}$).

LMVPF. This yields a MVPF of $\text{DE}^i_{\tau_i}/(\text{ME}^i_{\tau_i}+\text{BE}^i_{\tau_i}+\text{LE}^i_{\tau_i}) = 1.062\ [1.042, 1.083]$, represented in Figure E.8. That is, for each euro spent by Madrid's government cutting its wealth tax, Madrid's residents are willing to pay €1.062. The local MVPF of Madrid exceeds the closed economy MVPF that ignores the household locational effect. This is because the mobile tax base spurs added tax revenue for Madrid from other tax instruments. This confirms that as mobility is locally beneficial, for a tax cut, the closed-economy MVPF understates the local MVPF. Finally, in the calculation above, several components of the general MVPF formula are absent; Section E.4.2 provide arguments.

E.4.1.2 Social MVPF

The social MVPF is obtained by summing the Madrid WTP and net cost to the government of Madrid with the aggregate of each of these external effects.

SWTP. As there is no capitalization effect, the social marginal WTP reduces to the local marginal WTP which reduces to the local direct effect $\text{DE}^i_{\tau_i}$ of €$47,457$.

SNGC. The first component of the social marginal NGC is the local marginal NGC, €$47,457$. The second component is the external household locational effect $\sum_{j\neq i} \text{LE}^j_{\tau_i}$ equal to €$2,767$. Other regions of Spain lose wealth tax revenue, labor income tax revenue and capital income tax revenue. To obtain these, we use the causal estimates of the movers, and use a wealth tax simulator to calculate what their liabilities would have been had they stayed in their home region and faced that region's wealth tax simulator. Taking the average counterfactual taxes paid by a mover to Madrid, which assumes tax-induced moves to Madrid are proportional to all moves to Madrid,[11] we aggregate over the five years, to find a discounted loss of €1,124 in wealth tax revenue. In other words, even though movement to Madrid increases its tax base by 8.5%, the decrease to the rest of Spain is much smaller because Madrid is only a small fraction of all of Spain. In addition, the other regions use personal income tax revenues from labor and capital. As the capital tax schedule in all regions is the same, this is simply the causal estimate of the number of movers times the average capital taxes paid by movers to Madrid. The same is true for labor income taxes, but labor income tax rates differ across regions, so we adjust these upward by the average differential, though this

[10] Ideally, one would want to use the average taxes paid by individuals who move for tax reasons, however, this is unobservable. We assume individuals who move to Madrid for any reason are similar to individuals who move to Madrid for tax reasons.

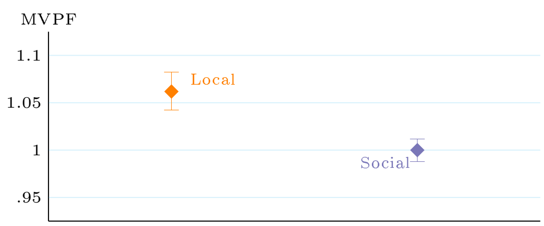
[11] Given regional tax differentials among other regions is small, this is reasonable.

differential is quite small for a rentier with limited labor income. This yields personal income tax losses of €1,642. As is clear, income taxes are a transfer between the rest of Spain and Madrid and so this cancels the household locational effect in Madrid's fiscal net cost. The loss in wealth tax revenue to the rest of Spain is, by coincidence, similar to the behavior effect gain in Madrid.

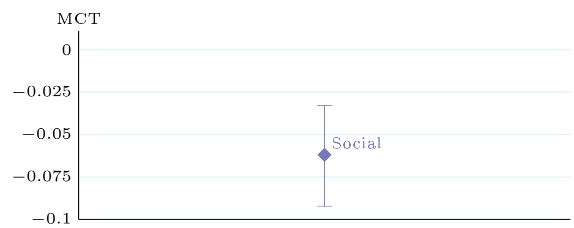
SMVPF. This entails a social MVPF of $\mathrm{DE}^i_{\tau_i}/(\mathrm{ME}^i_{\tau_i}+\mathrm{BE}^i_{\tau_i}+\mathrm{LE}^i_{\tau_i}+\sum_{j\neq i}\mathrm{LE}^j_{\tau_i}) = 0.999\ [.988, 1.012]$, represented in Figure E.8. For the above reasons, especially with respect to the government budgets, the social MVPF is very close to 1, the closed economy MVPF. Critically, for our purposes, the SMVP is significantly lower than the local MVPF of Madrid, highlighting the importance of interjurisdictional policy spillovers for welfare analysis.

(a) Marginal willingness to pay.

(b) Marginal net government cost.



(c) Marginal value of public funds.



(d) Marginal corrective transfer.

Figure E.8. MVPFs and MCT of a wealth tax cut. The upper-government considered is the national government. Bars represent 95% confidence intervals using parametric bootstrap.

Table E.10. Wealth tax cut, LMVPF, SMVPF and MCT.

		Local	External	Social
		Madrid	Other regions	Country
Willingness to pay				
Direct wealth saved	DE	1		1
	Total	1	0	1
Net government cost				
Mechanical expenditure	ME	1		1
Wealth, captial and income tax revenues	BE	−0.024		−0.024
Net cost of new residents	LE	−0.034	0.058	0.024
	Total	0.942	0.058	1
Marginal value of public funds	MVPF	1.062		1
Marginal corrective transfer	MCT			−0.062
Match rate	M			−0.058

E.4.2. Motivations for Ignoring Some MVPF Components

In the calculation of Appendix E.4, the capitalization into wages and prices is zero. Why? Agrawal, Foremny, and Martínez-Toledano (2024) show that only the tax differential with Madrid matters, and provide evidence that the "moves" are fraudulent rather than real. In other words, high wealth taxpayers simply switch their primary residence to a second home they already have. Further, these households represent less than 1% of the population. Thus, there is likely minimal house price capitalization. Moreover, these households are rentiers (mostly senior citizen) and thus wages are unlikely to adjust. Finally, we assume no effects on profits or firm mobility due to household wealth taxes. While it is conceivable business profits could be affected, given the moves are not real, this is also consistent with residents of Madrid not owning out-of-region businesses that high wealth individuals hold.[12]

The household locational effect could a priori include congestion costs on public services. As wealth taxpayers have very high wealth, these individuals do not consume much public services and a re net payers into the system. Thus, marginal congestion costs are likely zero.

E.4.3. Discussion

One lesson is that one needs not calculate the fiscal externality on every region individually. Rather, under reasonable assumptions about the distribution of movers, one can simply use the average tax

[12] Even if this were not true, there is no empirical evidence on this and more research is needed in this area.

rate of the affected regions. Of course, one interesting point is whether taxes have a direct effect of the willingness to pay of nonresidents. Theoretically, for a marginal change, there would be no effect. However, because our change is discrete, nonresident movers may have a positive willingness to pay for Madrid's low-tax deviation. In particular, Madrid's policy change can be viewed as a tax avoidance service for high wealth individuals outside of Madrid. If one took this view, then we can calculate the willingness to pay of nonresidents who avail themselves of this service. Given evasion comes with risk, the willingness to pay needs to be adjusted by the audit probability (approximately 1.5%) and the fine (100% of evaded taxes). Of course, given this is fraud, a federal planner may want to give zero weight to this. But if the planner gives full weight to it, then the SMVPF becomes 1.02, as the costs to the government are mainly transfers among the regions, but the zero tax rate in Madrid benefits nonresidents of Madrid by providing a means to avoid taxes.

E.5. Bidding for Firms

E.5.1. Institutional Background

Drawing on Slattery (2024) and Slattery and Zidar (2020), we consider the 2008 state subsidy deals offered to Volkswagen in order to attract the large plant to the state. A shortlist of states indexed by i make offers (bids), b_i, to attract the new plant. In 2008, Tennessee (TN) won the bidding competition and Volkswagen chose to locate their. Tennessee offered a winning bid of $b_{\text{TN}} = \$558M$, while Alabama (AL), which was the runner-up proposed a bid of $b_{\text{AL}} = \$380M$. After it located in Tennessee, Volkswagen was estimated to have created $\ell = 3,854$ jobs, as reported in Figure E.9. However, the overall causal evidence from Slattery and Zidar (2020) suggests that these created jobs actually only reduced existing jobs in other sectors of the local economy.

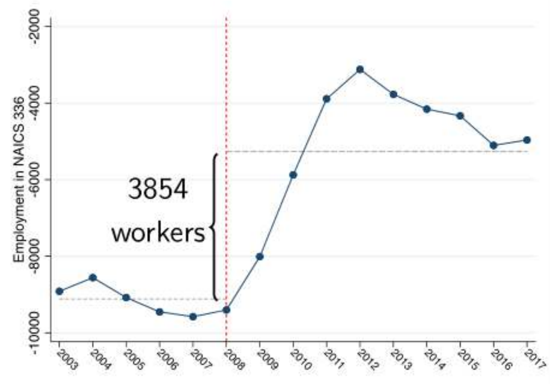


Figure E.9. Impact of the Volkswagen deal on local auto employment ([)source:][]Slattery2020.

We are interested in the decision of Tennessee to enter the bidding competition for Volkswagen. In the counterfactual scenario in which Tennessee would not have bid for the firm, the runner-up Alabama would have attracted Volkswagen. Table E.11 reports descriptive statistics which show that unlike Alabama, Tennessee does not tax income. Moreover, the industry wage and the average wage in all sectors of the economy in the regional area where the plant was to locate are lower in Tennessee than in Alabama. Anticipating the following analysis, these stylized facts suggest that Tennessee's tax revenue benefits of attracting Volkswagen should be lower than those Alabama would have made. This will play an important role in the level of the marginal corrective transfer.

Table E.11. Descriptive statistics, Tennessee and Alabama, 2008.

		Tennessee	Alabama
Bid (M$)	b_i	558	386
Income tax rate (%)	t_i^ℓ	0	3.3
Sales tax rate (%)	t_i^x	8.7	7.8
Industry wage ($)	w_i	50,500	68,400
Average wage ($)	$\overline{w}_i$	39,400	41,100
Contribution of Volkswagen to education (M$)	s_i	5.3	0
Created jobs	ℓ_i	3,854	0

Table E.11 shows that unlike Alabama, Tennessee obtained a commitment from Volkswagen that the firm provide a contribution to education. We assume that the state governments account for Volkswagen providing benefits to the state for a 20 years horizon, as this is a reasonable duration after which subsidy deals expire. Volkswagen will create jobs at a wage w_i. Given the causal evidence that subsidy deals do this at the expense of other sectors, any realized wage gains will only be those in excess of the prior wages, which we assume were at $\overline{w}^i$. So, using a 3% discount rate, the present discounted value of those future wages from created jobs are the net of $w^{\text{PDV}}_{\text{TN}} = \sum_{t=0}^{19} 50,500/(1+\delta)^t = \$773,852$ and similarly, $\overline{w}^{\text{PDV}}_{\text{TN}} = \$603,758$, $w^{\text{PDV}}_{\text{AL}} = \$1,048,148$ and $\overline{w}^{\text{PDV}}_{\text{AL}} = \$629,808$.

E.5.2. Conceptual Framework and MVPFs

We now introduce the MVPFs for the experiment of Tennessee entering bidding competition. To construct the MVPFs, we follow Slattery (2024) and treat the bidding process as an English auction. As Slattery explains Slattery 2024 [p.20–21][13] there are several characteristics of the English auction that correspond to the typical bidding process for these plants. The form of this auction provides us with useful information on the relationship between the bids in the winning location (TN) and the runner-up (AL). In particular, like capitalization reveals the willingness to pay in the education examples, the English auction is a powerful tool to revealing many components of the MVPF to us.

Properties of the English auction are essential to the calculation of the MVPFs. First, in the English auction, the stopping rule implies that the runner-up will bid exactly is valuation: $v_{\text{AL}} = b_{\text{AL}}$. Thus, the runner-up's valuation is perfectly revealed by the auction. Note, as in Slattery, this valuation is the valuation as perceived by politicians and not necessarily the true valuation absent political concerns. Thus, we follow Slattery (2024). The winning state will bid up to the firm's payoff in the runner-up location. In other words, the winning state will never bid more than

$$b_{\text{TN}} = b_{\text{AL}} + \pi_{\text{AL}} - \pi_{\text{TN}} \tag{E.1}$$

where π_j are Volkswagen's profits of locating in either state. Bidding anything higher than this will not change the probability of winning, but will lower the payoff the TN. As the winning state's payoff is $v_{\text{TN}} \geq b_{\text{TN}}$, we know that Tennessee must value the plant more than its bid.

E.5.3. Local MVPF

To construct the MVPF, we assume that there are no migration effects of households in response to attracting the Volkswagen plant. The local MVPF of Tennessee is then:

$$LMVPF = \frac{LWTP}{LNGC} = \frac{WTP_{\text{TN}}}{\text{ME}_{\text{TN}} + \text{BE}_{\text{TN}} + \text{PE}_{\text{TN}}}, \tag{E.2}$$

[13] We use the estimates from the 2020 working paper version of the paper.

where the marginal WTP, the mechanical, behavioral and price effects in Tennessee are:[14]

$$WTP_{\text{TN}} = v_{\text{TN}}, \quad \text{ME}_{\text{TN}} = b_{\text{TN}} - s_{\text{TN}}, \quad \text{BE}_{\text{TN}} = -t^{x}_{\text{TN}}\, \mathrm{d}x_{\text{TN}}, \quad \text{PE}_{\text{TN}} = -t^{\ell}_{\text{TN}} \mathrm{d}w_{\text{TN}}\ell = 0, \tag{E.3}$$

and v_{TN} is Tennessee's valuation for Volkswagen plant. Notice the denominator does not contain the costs of any business public services or added tax revenues of attracting Volkswagen (business location effect) because the costs of those services are likely a part of the subsidy deal and any taxes Volkswagen need pay locally were likely waived. The denominator is the local net government cost whose first component is the mechanical cost that Tennessee incurs by bidding, $b^{\text{TN}} = \$558M$. This cost is slightly reduced by Volkswagen's contribution to education, $s_{\text{TN}} = \$5.3M$. This amounts to a mechanical cost of $\text{ME}_{\text{TN}} = \$552.7M$. The mechanical cost is compensated by state and local sales tax revenues from any added jobs. Indeed, by hiring $\ell_{\text{TN}} = 3,854$ workers in the industry sector, Volkswagen increases the wage of each of these workers from $\overline{w}_{\text{TN}} = \$603,758$ to $w_{\text{TN}} = \$773,852$, as those workers primarily were in other sectors of the economy. This meas a wage increase of $\mathrm{d}w_{\text{TN}} = \$170,094$. we assume the share of taxable consumption in the individuals' income is of 50%.[15] Thus, attracting Volkswagen allowed Tennessee to raise $\text{BE}_{\text{TN}} = t^{x}_{\text{TN}}\, \mathrm{d}x_{\text{TN}} = -0.087 \times 0.50 \times 170,094 \times 3,854 = -28.35$ million dollars of sales tax revenues from the higher wages of the Volkswagen jobs. In sum, the local NGC of Tennessee is of $LNGC = \$524.35$.

Let us now turn to the WTP of Tennessee. Slattery (2024) provides a method to measure Tennessee's valuation of Volkswagen plant, $WTP_{\text{TN}} = v_{\text{TN}}$. Slattery assumes that across the many subsidy deals in her dataset, the runner up valuation takes the following functional form and estimates the regression equation:

$$v_i = \sum_k \alpha_k x_{ik} + \varepsilon_i \tag{E.4}$$

where i indexes the state, x_{ik} are state/local and firm (Volkswagen) characteristics k summarized in Table E.12.[16] We assume that this same functional form can be used to predict the valuation of the winner, with some error ε_i.

In our baseline model we assume that Volkswagen is primarily owned by non-residents of the

[14] The price effect due to the wage increase is zero because Tennessee does not tax income, as already mentioned.

[15] This percentage is significantly higher than the 35% used in our other empirical applications. As Tennessee and Alabama tax food unlike in most other U.S. states, taxable consumption represents around 50% of the individual income in Tennessee.

[16] When available, we take these characteristics from Slattery (2024). For all other characteristics, we obtain them from the same sources listed in Slattery (2024).

states of TN and AL, thus eliminating any ownership effects.[17] Volkswagen is primarily owned by non-residents of Tennessee, as TN is a small share of the U.S. population from which Volkswagen attracts financial investors, so that profits accruing to TN are so small that they are not a part of the local MVPF.

Table E.12. Estimates and calibration for the evaluation of ν_{TN}.

	Coef	SE	TN
Jobs promised (1,000)	281.33	25.85	2
Industry multiplier	11.45	8.73	14.28
Jobs x multiplier	−12.87	4.25	28.56
Investment planned	41.55	12.57	1
Corporate tax ($B)	8.7	8.91	6.5
Term-limited Gov	−43.53	26.22	1
Log (Per capita Income)	−149.01	80.16	3.67
Log (Industry Wage)	232.04	82.72	3.92
log(Wage) x log(Income)	−34.44	19.49	14.408
Change in Manuf. Emp			
Traditional Manuf	−74.56	28.71	−0.045
Unemployment Rate (%)			
Promise 1000+ Jobs	−9.76	7.05	5.7
Observations	209		
R-squared	0.78		

Equation (E.4) and Table E.12 allow us to predict Tennessee's' valuation. Thus, we apply the coefficient estimates to the Tennessee characteristics in order to obtain a predicted valuation $\hat{v}_{\text{TN}}$. But, we the error term is not observable. However, we know from the bidding auction theory that the valuation of the winners needs to be higher than its observed bid. Using the standard errors from the table, to this aim, we perform $10,000$ random draws of the coefficients in the spirit of a parametric bootstrap. These random draws allow us to obtain $10,000$ possible values of ε_i that can be added to $\hat{v}_{\text{TN}}$. As its bid is a lower bound of the valuation, we know that $\varepsilon_i > b_{\text{TN}} - \hat{v}_{\text{TN}}$, allowing us to calculate a conditional expectation. We compute Tennessee's estimated valuation as $\mathbb{E}[v_{\text{TN}}|v_{\text{TN}} \geq b_{\text{TN}}] = \hat{v}_{\text{TN}} + E[\varepsilon_i|\varepsilon_i > b_{\text{TN}} - \hat{v}_{\text{TN}}]$, yielding the conditional expectation of the error term. We obtain that the expected valuation of Tennessee (and thus the local WTP) is $LWTP = \$896.538M$. In sum, the local MVPF of Tennessee is $LMVPF = 1.71$.

[17] Indeed, the profits are separate variables not included the states valuation in Slattery (2024).

E.5.4. Social MVPF

The social MVPF of the federal government is:

$$SMVPF = \frac{LWTP + EWTP}{LNGC + ENGC} = \frac{WTP_{\text{TN}} + WTP_{\text{AL}} + \text{OE}}{(\text{ME}_{\text{TN}} + \text{BE}_{\text{TN}} + \text{PE}_{\text{TN}}) + (\text{ME}_{\text{AL}} + \text{BE}_{\text{AL}} + \text{PE}_{\text{AL}}) + \text{VE}} \tag{E.5}$$

where WTP_{TN}, ME_{TN}, BE_{TN} and PE_{TN} are as defined in (E.3). The external willingness to pay, $EWTP$, includes both the aggregate willingness to pay in Alabama and the ownership effect on the owners of Volkswagen assumed to be living in the federation but outside of Tennessee. These are:

$$WTP_{\text{AL}} = -v_{\text{AL}} \qquad \text{OE} = -\left(\pi_{\text{AL}} - \pi_{\text{TN}}\right), \tag{E.6}$$

and the external mechanical, behavioral and price effects on the government costs are:

$$\text{ME}_{\text{AL}} = -(b_{\text{AL}} - s_{\text{AL}}), \qquad \text{BE}_{\text{AL}} = -(-t^{x}_{\text{AL}}\,\mathrm{d}x_{\text{AL}}), \qquad \text{PE}_{\text{AL}} = -(-t^{\ell}_{\text{AL}}\mathrm{d}w_{\text{AL}}\ell), \tag{E.7}$$

where each has a negative in front because when Tennessee wins the plant it “steals” the plant from the runner-up. Finally, the vertical effect on the federal government cost is:

$$\text{VE} = -t^{\ell}_{\text{F}}(\mathrm{d}w_{\text{TN}} - \mathrm{d}w_{\text{AL}})\ell. \tag{E.8}$$

Comparing the local effects in (E.3) and the external effect in (E.7), it appears the effects on Alabama are systematically considered with opposite signs by the federal planner. The reason is intuitive: if Tennessee does not bid, then Volkswagen would locate in the runner-up state (Alabama). Thus, from a social perspective, all the benefits and costs in Alabama are foregone benefits and costs. No other states enter into the WTP of the federal government because the runner-up state determines the “opportunity cost” of the plant to the federal government.

Now, let us start with quantifying the net government cost. The mechanical effect in Alabama reduces to the benefits of its saved bid, $\text{ME}_{\text{AL}} = -\$386M$. The sales tax revenues that Alabama does not collect from the increase in consumption that the implementation of Volkswagen would have generated represent a cost of $\text{BE}_{\text{AL}} = 0.078 \times 0.5 \times 418,340 \times 3,854 = 62.879$ million dollars.[18]

[18] Notice that we assume that the number of job created in Alabama (3,854) would have been identical to what was created in Tennessee, because this counterfactual value is unobservable, but reasonable it would have had similar size effects on the economy.

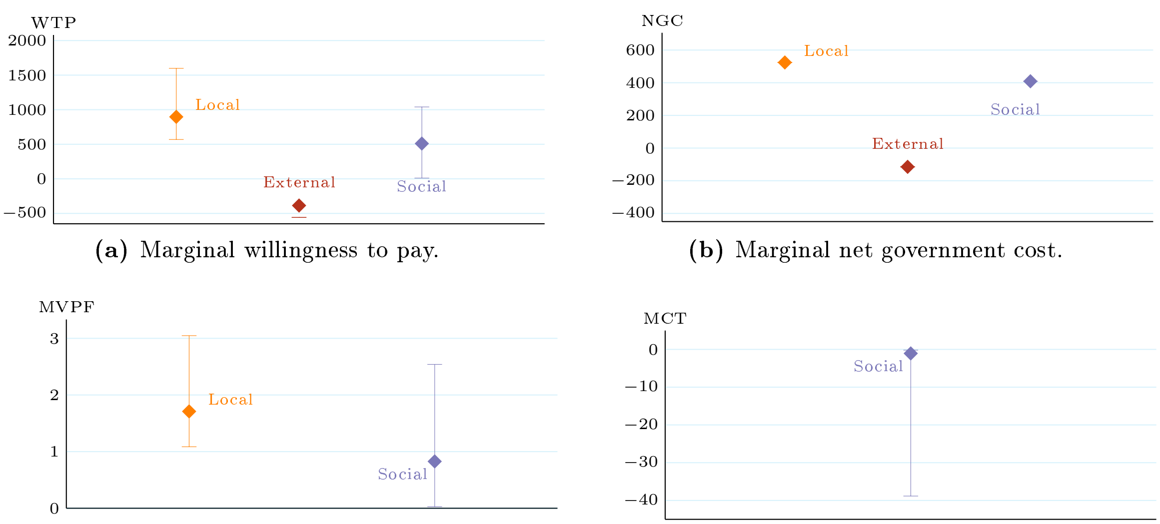
Unlike Tennessee, Alabama taxes labor income; these foregone tax revenues amount to a social cost of $\text{PE}_{\text{AL}} = \$53.205M$. The federal government also taxes income. Given that the wage bonus in the industrial sector compared to others is higher in Alabama than in Tennessee, this represents an extra cost of $\text{VE} = \$154.992M$ in foregone federal income tax revenues. In sum, these costs reduce considerably the gain of Alabama's saved bid, so that the external net government cost is $ENGC = -\$114.924M$, that is a tax revenue gain of $\$115M$. Adding the local and external net government costs, we obtain a social NGC of $SNGC = \$409.424M$.

Finally, let us turn to the social willingness to pay. The external willingness to pay, $EWTP = -(v_{\text{AL}} + \pi_{\text{AL}} - \pi_{\text{TN}})$ includes both the foregone value of Volkswagen's plant in Alabama, v_{AL}, and the additional profits that the owners of the firm would have received had Volkswagen located in Alabama, $\pi_{\text{AL}} - \pi_{\text{TN}}$. The form of the English auction (Section E.5.2) makes it particularly easy to assess the SWTP. Indeed, recalling that any state that lost the bidding auction proposed the maximum bid it could, that is its valuation. Thus, Alabama's valuation is simply its bid, $v_{\text{AL}} = b_{\text{AL}}$. Inserting this valuation into the external WTP (E.6) and comparing with Tennessee's bid (E.1), it appears that the external WTP is an opportunity cots of $EWTP = -(b_{\text{AL}} + \pi_{\text{AL}} - \pi_{\text{TN}}) = -b_{\text{TN}} = -\$558M$. Intuitively, the external willingness to pay are all the foregone net benefits that the society would have benefited from had Volkswagen located in Alabama. Yet, to win the bidding competition, Tennessee has to provide a subsidy that covers all these forgone benefits. As we observe the bid of Alabama, we can decompose the external willingness to pay into the external valuation in Alabama, $v_{\text{AL}} = -\$386M$ and the ownership effects on business owners, $\text{OE} = \$172M$. It follows that the social WTP is $SWTP = \$339M$ and the social MPVF is $SMVPF = 0.827$. It is lower than the LMVPF (1.71) so that the MCT is negative (a tax) $MCT = -1.068$ at a match rate of $M = -0.516$. Subsidy competition can have efficiency improving effects if it allows firms to better match to states (Black and Hoyt 1989). However, the competitive effects of subsidy competition generate waste for society. Table E.13 and Figure E.10 summarize the results in this section:

Table E.13. Bidding competition, LMVPF, SMVPF, MCT and match rate.

		Local	External		Social
		Tennessee	Alabama	Fed	Fed
Willingness to pay					
Valuation for the policy	ν_i	897	−386		511
Profit ownership	$\pi_{\text{AL}} - \pi_{\text{TN}}$			−172	−172
	Total	897	−386	−172	339
Net government cost					
Bid net of firm contribution	ME	553	−386		167
Sales tax revenue	BE	−28	63		35
Income tax revenue	PE	0	53		53
Federal income tax revenue	VE			155	155
	Total	524	−270	155	409
Marginal value of public funds	MVPF	1.71			0.827
Marginal corrective transfer	MCT				−1.068
Match rate	M				−0.516

Note— All values are in million dollars. By definition, the external net government cost includes all external net costs so that $ENGC = -115$ millions of dollars.



(a) Marginal willingness to pay.

(b) Marginal net government cost.

(c) Marginal value of public funds.

(d) Marginal corrective transfer.

Figure E.10. MVPFs and MCT of biding for firms. The upper-government considered is the federal government. Bars represent 95% confidence intervals using parametric bootstrap.

E.5.5. Ex-ante MCT

Finally, we consider an alternative assumption about job creation. The above MVPF and MCT estimates assume that new jobs created by Volkswagen only crowd out existing jobs. This correspond to actual ex-post evidence of the effects of Volkswagen's new plant in Tennessee. Alternatively, Slattery and Zidar (2020) also report policy maker's ex-ante belief of job creation that can be found in, so-called "impact studies". These ex-ante beliefs compute the wage gain in a state by assuming that the number of jobs promised by Volkswagen in the industry sector (2,000 jobs paid $\$50,500$) do not crowd out jobs in other sectors. In addition, they assume that agglomeration benefits entail multiplier effects in the economy so that $m \times 2,000$ (where $m = 14.28$ is a job multiplier) extra jobs are created in other sectors of the economy (paid $\$39,400$).

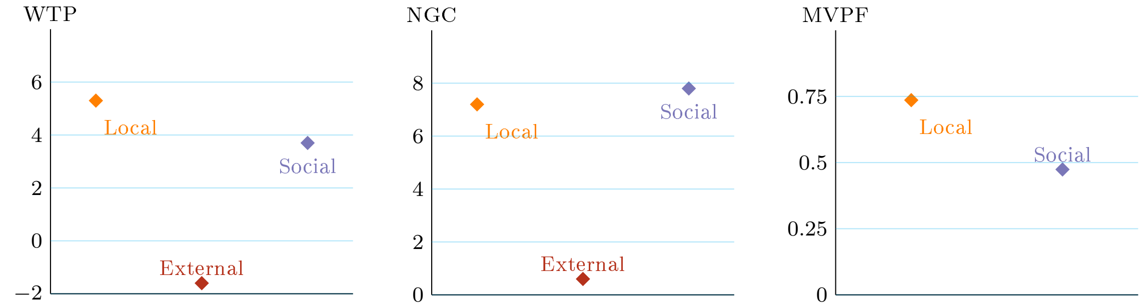
Table E.14. Bidding competition, with ex-ante prior on job creation.

		Local	External		Social
		Tennessee	Alabama	Fed	Fed
Willingness to pay					
Valuation for the policy	ν_i	897	−386		511
Profit ownership	$\pi_{\text{AL}} - \pi_{\text{TN}}$			−172	−172
	Total	897	−386	−172	339
Net government cost					
Bid net of firm contribution	ME	553	−386		167
Sales tax revenue	BE	−813	783		−29
Income tax revenue	PE	0	663		663
Federal income tax revenue	VE			209	209
	Total	−260	1060	209	1009
Marginal value of public funds	MVPF	∞			0.335
Marginal corrective transfer	MCT				$-\infty$
Match rate	M				−1

Under this approach, wage capitalization is much higher so that more income and sales tax revenues can be collected by the states. Table E.14 shows that under ex-ante beliefs, Tennessee expects large extra tax revenues so that the policy pays for itself at the local level. This is not the case at the social level because jobs created by Tennessee are still essentially jobs lost by Alabama. This large overstating of local benefits by Tennessee imply that the federal government now fully precludes the policy with an infinitely negative MCT (i.e. $MCT = S/LNGC$, with $S < 0$ and $LNGC < 0$) and a confiscatory match rate of −1 dollar per total dollar spent on bidding by Tennessee.

E.6. Flood Protection

Figure E.11 summarizes the results.



(a) Marginal willingness to pay **(b)** Marginal net government cost **(c)** Marginal value of public funds

Figure E.11. MVPFs, flood protection. The MCT is a tax of −0.55 per marginal dollar spent locally and the match rate is −0.35.

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