The Marginal Value of Public Funds in a Federation

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Abstract

Our objective is to establish and provide a framework for quantifying the welfare effects of fiscal policies in an open economy, with an emphasis on state and local governments in a federalist system. To do this, we develop a model of fiscal policy when there are spillovers and mobility effects from changing taxes and expenditures among competing local jurisdictions. We then derive how mobility and spillovers influence the marginal value of public funds (Hendren 2016). Because a federal planner internalizes the interjurisdictional externalities, the MVPF for a federal and local planner can diverge substantially. We provide guidance on the additional empirical components of the marginal value of public funds necessary to understand the welfare effects of policies in a federalist system.

JEL: H22, H25, L10, L50, D50

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1 Introduction

The "credibility revolution" has had profound effects on empirical analysis in economics and, in particular, the interpretation and understanding of the effects of policy interventions on numerous economic measures. These causal estimates are useful to determining the welfare effects of policies. Hendren (2016) derives and Finkelstein and Hendren (2020) summarize how the marginal value of public funds (MVPF) – the ratio of the marginal benefit of a policy to the net marginal cost to the government of the policy – is a useful and transparent framework to map causal effects to welfare analysis. Critically, the net marginal cost is inclusive of how behavioral responses impact the government budget. Hendren and Sprung-Keyser (2020) then applies the MVPF to study 133 policy changes in the United States, calculating the MVPF, using empirical estimates in the literature. But, in a fiscal federation like the United States, Canada, Switzerland, India, or Brazil, the MVPF of a subnational policy change depends critically on whether it is determined from the perspective of the federal or local government.

To make a sweeping generalization, as noted by Wildasin (2021), many models in economics and public finance often implicitly assume that policies "are made by a unitary [central] government, that they apply to a fixed group of households and firms, and that economic interactions with the rest of the world may safely be ignored." However, state and local governments set policy in an open economy setting where people and factors are mobile across jurisdictions (Kleven et al., 2020; Suárez Serrato and Zidar, 2016; Fajgelbaum et al., 2019), where fiscal policies of one jurisdiction have spillover benefits on residents of other jurisdictions (Case et al., 1993), where the costs of public services rise due to congestion (Wildasin, 1980; Scotchmer, 2002), and where jurisdictions compete and possibly interact strategically with each other (Agrawal et al. 2020; Brueckner 2003). These forces that shape how local governments make policy alter how we think about the welfare consequences of policy. But this literature has struggled to draw welfare implications. One reason, which we focus on, is that the objectives of a local planner diverge substantially from a federal planner. While a local government does not account for how a marginal change to its policy influences the government budget in other jurisdictions or the spillover benefits to non-residents, a federal planner will account for these effects. The welfare implications of decentralized policymaking depend critically on whether being evaluated from the perspective of a local or federal government. Thus, important questions relating to the welfare effects of decentralized policymaking remain unanswered.

Our objective in this paper is to establish and provide a framework for quantifying and calculating the welfare effects of fiscal policy — both taxes and spending — in a fiscal federation in which there are spillovers (broadly defined) from fiscal policy in other jurisdictions. This framework, outlined in the following sections, applies the concept of MVPF into a general model of fiscal federalism with mobile factors and then uses causal estimates of tax spillovers and capitalization to obtain a measure of the MVPF following Hendren and Sprung-Keyser (2020). Our model features multi-tiered governments common to decentralized federations around the world, allowing us to derive the parameters necessary to determine how a central planner's MVPF would differ from a local government's MVPF. Critically, our MVPF nests the closed economy case, allowing us to compare how the MVPF changes when accounting for spillover and mobility effects. Our model allows us to generalize the applicability of the MVPF to a variety of important policies.

In general, the marginal value of public funds is the ratio of the marginal benefit to the marginal cost. Although we usually talk about a policy which is budgetary costly, MVPF is more general and includes policies which might be budgetary beneficial (e.g., increase in top income tax rate). The MVPF is traditionally operationalized as the willingness to pay out of beneficiary income relative to the net cost of the government of the policy per beneficiary. The denominator can be expressed as the mechanical cost of the policy plus the fiscal externality. The mechanical cost is the increase in government expenditures due to the policy (absent any behavioral responses). In the absence of mobility, the fiscal externality – not to be confused with the fiscal externality on other jurisdictions in open economy models – is the effect of any behavioral responses from the policy on own-government net budget outlays. The fiscal externality accounts for the effect of both marginal and inframarginal individuals on government spending and tax revenue.

In order to define the MVPF in a federal system, we first need to specify "whose MVPF?" — a single local government or a federal government. We first derive the "local" MVPF, or LMVPF, which is the MVPF in the locality changing the policy. The local MVPF only accounts for the willingness to pay of the local government and the net cost on its own budget. As a result, the local government only accounts for mobility in so much as it affects itself. In addition to the local MVPF, we also derive other MVPF concepts. Because the benefits of public services spillover across jurisdictions, because mobility affects prices in other jurisdiction, and because tax changes impose fiscal externalities on nearby jurisdictions, a policy change in one jurisdiction has an "external" MVPF in other jurisdictions. The "external" MVPF, or EMVPF, is the willingness to pay and the net cost to a jurisdiction resulting from a nearby or competitor jurisdiction change its policy. Intuitively, consider the example of education provided in jurisdiction i. Nonresidents in jurisdiction

j may benefit from education in nearby jurisdictions and thus have a positive willingness to pay for the other jurisdiction providing education, making jurisdiction j's MVPF for i's spending on education nonzero. At the same time, increases in i's spending on education increases migration to the jurisdiction from jurisdiction j, which implies budgetary impacts on jurisdiction j. In addition, this mobility may affect house prices and wages in jurisdiction j, also influencing the willingness to pay of the policy. Finally, outflight of residents may change the costs of providing public services in jurisdiction j, which implies a further budgetary impact in that jurisdiction. If these spillovers are global in nature (environmental protection of airborn global pollutants), then these spillovers to any one other jurisdiction may be negligible. But, even though the effect on any one jurisdiction may be small, the aggregate external effect summed over many small municipalities may still be large. On the other hand, if these spillovers are local in nature (public roads), then these cross-jurisdiction effects may even have a potentially large effect on a small number of nearby jurisdictions.

Given these external effects, we then consider the MVPF of a federal planner that accounts for spillovers. In particular, one may be interested in evaluating the overall effect of a policy change in a single state on the entire federal economy. We call this the "social" MVPF, or SMVPF. Critically, the federal planner's MVPF is the separate aggregation of the numerators and denominators of the local MVPF and external MVPFs (summed over all jurisdictions), where the willingness to pay must be weighted by the planner's welfare weights. In other words, if jurisdiction i is considering increasing education spending, the social willingness to pay is the willingness to pay of jurisdiction i plus the weighted willingness to pay for all other jurisdictions in the economy. Finally, the net cost to the government is the mechanical effect plus the own-jurisdiction fiscal externality inclusive of congestion costs in jurisdiction i plus the interjurisdictional fiscal externality inclusive of congestion costs imposed on all other jurisdictions.

Thus, in a federal system, the functional form of the MVPF remains the same as Hendren (2016), but measuring the willingness to pay and the marginal cost become more nuanced, requiring estimation of additional terms. In an open economy, local willingness to pay is still based on the change to indirect utility from the policy. This includes the direct effect of the policy on utility as in Hendren (2016), but now also features an (novel) indirect effect of the policy on disposable income resulting from wage and rent changes. This latter effect can be interpreted as the effect of household mobility on utility. Intuitively, if a jurisdiction becomes more attractive from a policy change, mobility capitalizes the policies into wages and rents. In addition, changes in the profitability of firms may change the willingness to pay depending on the ownership structure of firms by residents and nonresidents.

With respect to the denominator of the MVPF, our model features the same two effects as in Hendren (2016): the direct (mechanical) effect of the policy on the budget deficit holding behavioral responses constant and a behavioral effect resulting from how the policy changes individual behavior, thus affecting the government budget. In addition, open economy concerns imply that there are three novel channels by which the marginal cost is affected by the policy. First, the policy change results in mobility. Mobility alters the fiscal bases and revenues of the jurisdiction from all taxing instruments paid by the household. Second, that mobility alters wages and land rents across jurisdictions to restore spatial equilibrium and the changes wages and rents results in change tax revenue in the jurisdiction. Among local governments, we know that mobility and sorting across jurisdiction boundaries – and thus the capitalization into wages and house prices – is nontrivial, resulting in important effects on the local MVPF. Finally, because local public services can be congestible, changes in the number of residents and thus beneficiaries from public services, changes the costs of providing public services.

Each of the above components of the local MVPF influence other jurisdictions. One jurisdiction's gain in terms of residents is another jurisdiction's loss. Moreover, public services can directly benefit nonresidents, inducing a positive willingness to pay for services outside of the jurisdiction of residence. These effects thus influence the external MVPF, and because a social planner accounts for these effects, may result in a substantial divergence with the local planner's welfare assessment of the policy.

Consider a specific example the local MVPF from an increase in education spending. First, the mobility of people across jurisdictional (or school district) boundaries influences the government budget of the jurisdiction implementing the policy. In addition to influencing the direct cost from providing more education, the inflight of new residents raises tax revenue, but this effect is mitigated by congestion costs. Furthermore, government revenue also changes as a result of capitalization into house prices or wages. Second, because the mobility into the jurisdiction also changes wages, house prices, and potentially profits, that alters the willingness to pay for more schooling.

To determine the social MVPF, one must also consider the external effect on other jurisdictions. First, an increase in education spending one jurisdiction imposes an *interjurisdictional* fiscal externality – defined as the effect of mobility on net budget outlays of other jurisdictions. For example, increasing education spending in Cambridge may result in mobility to Boston, lowering tax revenue in Boston. In addition, this mobility also affects equilibrium wages and rents via capitalization in

Boston, influencing the revenue raised in the city. Any revenue losses from mobility might be muted somewhat by a decline in the costs of providing goods because less residents must be serviced in Boston. Second, and especially likely the case for many municipal public services, increasing education spending in Cambridge may induce positive spillover benefits on other individuals outside of the jurisdiction by making them more productive. As a further example, infrastructure policy may benefit nonresidents. This implies a positive willingness to pay for Cambridge's policy change by nonresidents living in Boston. Of course, the willingness to pay of this policy is also influenced by the changes in prices and profits in the jurisdiction.

Of course, jurisdictions may strategically react to the policy reforms of other jurisdictions: a tax decrease in Massachusetts may also trigger a tax decrease in Connecticut and these reactions may affect the willingness to pay and marginal cost of a policy. For simplicity, we omit these effects from our baseline model. If jurisdictions are atomistic — as is likely the case for local governments — then the competition that occurs is of the perfectly competitive form, and no strategic interactions arise. Of course, even local governments may have some market power resulting in strategic interactions. We extend the model to account for this possibility, finding that the intensity of the strategic interactions then influences the MVPF by the second round reactions of other governments.

We derive formal expressions for the MVPF for the same tax and spending instruments considered in Hendren (2016). Because of its importance in local public finance, we add a local property tax to the mix. In this context, we are able to show that when people are immobile, then wages and housing rents are constant, and the MVPF reduces to that in Hendren (2016). Mobility thus complicates the number of parameters necessary to calculate the MVPF. In addition to the information needed in Hendren and Sprung-Keyser (2020), the researcher needs to know the mobility elasticity as well as measures of capitalization, but these are all parameters that are often estimated in the local public finance literature, especially for local tax policy and local education spending. We provide empirical guidance on how to select these parameters.

Like in Hendren (2016), our derivation of the MVPF is quite general. In order to gain intuition, we nest the MVPF derivation in a spatial general equilibrium model similar to Kline and Moretti (2014), Moretti (2011) and Suárez Serrato and Zidar (2016). The spatial general equilibrium model allows us to derive illustrative examples of how taxes and spending affect mobility, wages, rents, and other behavioral responses. Then, under these reasonable conditions, we can determine whether an estimate of the MVPF that ignores open economy considerations is an upper or a lower bound of the true local MVPF. We can also easily compare the MVPF of the local planner and social planner, determining which is larger simply based on the comparative statics of our spatial general equilibrium model.

In general, determining the relationship of the SMVPF, LMVPF, and an MVPF that ignores mobility is complex, but our spatial general equilibrium model provides us with analytical results. Consider local spending on education programs, which generally have a high marginal costs of public funds. Then, can we rank the relative magnitudes of the closed economy MVPF, the LMVPF, and the SMVPF? For a two-jurisdiction economy in which the individual housing demand and labor supply are fixed, we show that this ranking critically depends on the relative strength of agglomeration and dispersion forces.

If public and private agglomeration forces are relatively high, the closed economy MVPF underestimates the local MVPF. Indeed, by attracting new residents, public good provision increases the local wage and the residents' disposable income. The jurisdiction also benefits from more property and labor tax revenues due to the wage and housing price increase from capitalization. On the contrary, if dispersion forces are high, the reverse holds: the closed economy MVPF overestimates the local MVPF.

Moreover, if agglomeration forces are relatively high, the social MVPF is smaller than the local MVPF for the same reasons. The LMVPF ignores that an increase in the local public provision reduces the number of residents in the other jurisdictions, and thus the welfare and public budget benefits from agglomeration, from which non-residents enjoy. If however, dispersion forces are high, the social MVPF becomes larger than the local MVPF.

Finally, we conclude with a practical discussion of how researchers can estimate our various MVPFs. We discuss the advantages and disadvantages of aggregate data, what effects need to be identified separately or jointly, and how to estimate interjurisdictional fiscal externalities. We also provide guidance for new parameters that the empirical literature would be well-suited to estimate empirically.

1.1 Background on the MVPF

Although recently popularized in several papers by Hendren, the MVPF has a long history. Understanding the welfare costs of public policies often follows the marginal excess burden approach adopted by Harberger (1964). Many economists have constructed various measures of non-budget neutral policies including marginal excess burden and marginal costs of public funds (Stiglitz and Dasgupta, 1971; Atkinson and Stern, 1974; Wildasin, 1979, 1984; Auerbach, 1985; Fullerton, 1991;

Auerbach and Hines, 2002; Dahlby, 2008). The basic application of studying the welfare effects of non-budget neutral policies using the approach adopted in this paper dates back to Mayshar (1990), Slemrod and Yitzhaki (1996), Slemrod and Yitzhaki (2001), and Kleven and Kreiner (2006). The approach of these authors has the advantage of relying on causal effects on non-budget neutral policies and does not require estimating compensated elasticities. A second advantage is that comparisons across policies translate into comparisons of the social welfare effects of policies.

Before proceeding to our model, we summarize the definition of the MVPF and explain how it relates to other welfare metrics.

The MVPF can be defined as

$$MVPF = \frac{\text{Beneficiaries' Willingness to Pay}}{\text{Net Cost to Government}}, \tag{1}$$

or alternatively,

$$MVPF = \frac{W}{1 + FE}, \tag{2}$$

where W is the willingness to pay (from their own income) of inframarginal recipients for each dollar of the program. And where FE is the fiscal externality – or the cost on the government budget – per dollar increase in the mechanical expenditures per inframarginal beneficiaries. Of course, these definitions can also apply to taxes rather than government expenditures. Note that if the denominator of the MVPF is negative, the program is said to "pay for itself." An example would be a tax cut that increases government revenue. In this case the MVPF is negative, but Hendren and Sprung-Keyser (2020) define this as having an infinite MVPF, to make it clear the programs are "better" than programs with finite but positive MVPFs. Then, to compare the welfare effects of different policies, we can assume the all beneficiaries of a given (targeted) policy have the same social marginal utility of income. Then if η_i is the social marginal utility of policy i, a change in spending on policy 1 that is financed by policy 2 will increase welfare if

$$\eta_1 MVPF_1 \geq \eta_2 MVPF_2. \tag{3}$$

In this way, the MVPF quantifies the tradeoff society faces in determining fiscal policies.

The MVPF contrasts with more familiar concepts such as the marginal excess burden, which is the welfare effect of a policy while requiring beneficiaries to pay for the policy with individual-specific lump sum transfers. Thus, because of these transfers, its estimation requires estimating compensated elasticities. Thus, marginal excess burden closes the budget constraint via an unrealistic approach. In contrast, the MVPF translates into a welfare measure by comparing two policies that create a hypothetical budget neutral policy. This latter thought experiment is much more realistic, especially in open economy applications that we will discuss. Local governments are characterized as offering a "package deal" of many services, which allow us to form a hypothetical policy package to create a budget neutral thought experiment.

An alternative approach to welfare is to use the marginal cost of public funds, estimated as approximately 0.3 (Poterba, 1996). Then, one can compare the benefits of a policy to the cost of the government, which is one plus the marginal cost of public funds. An alternative variant of the marginal cost of public funds is to assume that revenue is raised via a linear income tax that distorts behavior. But, there are alternative ways to raise revenue, especially at the local level, where income taxes represent a trivial part of tax revenue. In this way, the marginal cost of public funds varies across taxing instruments, at the MVPF has the advantage of breaking the link between spending and taxes.

2 Model

Although our ultimate goal is to derive expressions for the MVPF in a federalist system within an open economy, we first start by sketching a spatial general equilibrium model that will provide intuitive expressions for how government policies affect mobility, and thus capitalization and incidence. Our spatial general equilibrium model draws inspiration from regional models like Kline and Moretti (2014), Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2019) in which individuals work in the place of residence, but differs from urban models in line with Ahlfeldt et al. (2015) in which individuals commute outside of the place of residence. None of our MVPF derivations will depend on this model.

2.1 Household

The national economy consists of M jurisdictions (states or localities) indexed by $i = 1, \ldots, M$ with population n_i. Homogeneous individuals are mobile across jurisdictions in the federation that includes N households who only differ with respect to their taste for jurisdiction i, denoted e_i. Each resident of jurisdiction i is employed there, receiving wage w_i and purchases housing there at a rent p_i per unit of housing.

The representative resident of jurisdiction i has the following separable utility function:

$$U_i + e_i = U(x_i,\, \ell_i,\, h_i,\, \underbrace{g_i,\, g_i^F,\, \mathbf{g}_{-i}}_{\mathbf{g}}) + e_i \tag{4}$$

where x_i is the consumption of a tradeable, private numéraire good, g_i is the amount of public services provided by jurisdiction i, g_i^F is the amount of the federal public services provided to the residents of jurisdiction i, ℓ_i is the amount of labor supplied, and h_i is housing consumption. Due to expenditure spillovers (Case et al., 1993), residents of i benefit from the public goods provided by the other jurisdictions $\mathbf{g}_{-i} = (g_1, \ldots, g_{i-1}, g_{i+1}, \ldots, g_M)$. As examples of budgetary spillovers, roads in one jurisdiction can be used by nonresidents, school expenditures can benefit other states because children move after college or because workers compete though the product market, or citizens in one state might care about poverty/inequality in other states and derive utility from those states' social assistance programs. The utility function is increasing with respect to each of its arguments. We assume that $\partial U_i/\partial g_i > \partial U_j/\partial g_i > 0$, for all $j \neq i$ which means that local public goods marginally provide more satisfaction to local residents than to residents of neighboring jurisdictions.

We proceed by considering that both the state and federal governments raise revenue from the same four taxes: a commodity tax, an income tax, a property tax, and a head tax (alternatively, cash transfer). The commodity, income, and head taxes are considered in Hendren (2016); given our interest in local government policies and that, at least in the United States, the property tax is a major source of local revenues, we include it as well.

In addition to labor earnings received in their jurisdiction of residence, individuals also receive residual profits (π) from the production of the private numéraire good and housing. Initially, as we focus on policies directed at households, we assume that these profits are distributed equally among individuals regardless of where they reside. These profits, along with possible jurisdiction-specific nonlabor income (η_i), compose the individual non-labor income, $y_i(\pi)$. Then, the household budget constraint is:

$$(1 + t_i^h + t_F^h)p_i h_i + (1 + t_i^x + t_F^x)x_i = y_i(\pi) + (1 - t_i^\ell - t_F^\ell)w_i \ell_i - t_i^n - t_F^n \tag{5}$$

where t_i^h and t_F^h are the ad valorem property taxes for the state (i) and the federal government (F), t_i^x and t_F^x are the ad valorem commodity taxes, t_i^ℓ and t_F^ℓ are the ad valorem labor taxes and t_i^n and

t_i^n are head taxes, which also act as possible government expenditures via cash transfer.

We assume that the individual maximizes her utility choosing her housing consumption h_i and labor supply ℓ_i and adjusts her composite consumption x_i so as to satisfy the budget constraint (5).

The individual's optimal choice of x_i, h_i and ℓ_i is characterized by the first-order conditions. and define the Marshallian demands for x_i and h_i, and labor supply ℓ

$$x_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}), \qquad h_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}), \qquad \ell_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}), \tag{6}$$

where $\mathbf{t}_i = \left(t_i^x,\, t_i^h, t_i^\ell,\, t_i^n, t_F^x,\, t_F^h, t_F^\ell,\, t_F^n\right)$, the vector of taxes in jurisdiction i inclusive of federal taxes and $\mathbf{g} = (g_i, g_i^F, \mathbf{g}_{-i})$ is the vector of public goods provided in the economy. Inserting these Marshallian demands and supply into (4) defines the indirect utility function

$$V_i + e_i = V(p_i, w_i, y, \mathbf{t}_i, \mathbf{g}) + e_i \tag{7}$$

2.2 Private sector production

We assume that m_i identical firms produce the numéraire good. Let the production technology for the firm be denoted by the function

$$f_i = f_i\left(l_i, L_i, \mathbf{z}\right) \tag{8}$$

where l_i is the labor employed by each firm. Productivity is also affected by public investments (infrastructure, for example) in both jurisdiction i and as a result of spillovers, possibly other, neighboring jurisdictions where $\mathbf{z} = (z_1, \ldots, z_M)$ denotes the vector of investment with element z_j denoting investment in jurisdiction j. Total employment in the jurisdiction, $L_i = m_i l_i$, may affect firm productivity because of economies of agglomeration. The production technology for each firm exhibits positive but decreasing marginal returns with respect to labor, i.e. $\partial f_i/\partial l_i > 0$ and $\partial^2 f_i/\partial l_i^2 < 0$. Public investment in the jurisdiction will increase productivity and investment in neighboring jurisdictions and will not decrease it, i.e. $\partial f_i/\partial z_i > 0$ and $\partial f_i/\partial z_j \geq 0,\ j \neq i$. Moreover, the business public service increases the marginal productivity of a worker $\partial^2 f_i/\partial z_i \partial l_i > 0$ and $\partial^2 f_i/\partial z_j \partial l_i \geq 0,\ j \neq i$.

Economies of agglomeration imply that the production of an individual firm increases with respect to the total labor force of the jurisdiction, i.e. $\partial f_i/\partial L_i >\ 0$, and that the marginal product of a worker employed by a firm also increases with respect to L_i, i.e. $\partial^2 f_i/\partial L_i \partial l_i$. To simplify our notation, let

$$F_i\left(L_i, \mathbf{z}\right) \equiv m_i f_i\left(\frac{L_i}{m_i},\, L_i, \mathbf{z}\right)$$

be the aggregate production function in jurisdiction i. The profit of a firm is:

$$\pi_i^f = f_i - w_i l_i,$$

The firm choses its labor demand to maximize its profit, (2.2), so that the usual first-order condition is obtained:

$$\frac{\partial f_i}{\partial l_i}\left(\frac{L_i(w_i, \mathbf{z})}{m_i},\, L_i(w_i, \mathbf{z}), \mathbf{z}\right) = w_i \tag{9}$$

in which we have substituted $l_i = L_i/m_i$ after differentiation. Condition (9) defines the labor demand of a firm in i, denoted $l_i(w_i, \mathbf{z})$ and thus the total labor demand $L_i(w_i, \mathbf{z}) = m_i l_i(w_i, \mathbf{z})$ in jurisdiction i.

Inserting this labor demand into the profit expression (2.2) and multiplying by the number of firms m_i, we obtain the profit function of jurisdiction i:

$$\pi_i^x(w_i, \mathbf{z}) = F_i\left(\frac{L_i(w_i, \mathbf{z})}{m_i},\, L_i(w_i, \mathbf{z}), \mathbf{z}\right) - w_i L_i(w_i, \mathbf{z}). \tag{10}$$

The housing stock, H_i in jurisdiction i is produced with capital and land according to the increasing and convex cost function $c_i^h(H_i)$. The housing sector chooses H_i so as to maximize profit:

$$\pi_i^h = p_i H_i - c_i^h(H_i) \tag{11}$$

Let $H_i\left(p_i\right)$ and $\pi^h(p_i)$ denote the resulting supply and profit functions, respectively. Differentiating, we obtain:

$$H_i'(p_i) = \frac{1}{c^{h\prime\prime}(H_i)} > 0 \qquad\qquad \pi_i^{h\prime}(p_i) = H_i > 0 \tag{12}$$

where the second equality uses the envelop theorem.

2.3 Public service production

As individuals are mobile across jurisdictions, the cost of providing the public service might change as residents move in and out of the jurisdiction. Moreover, because of spillover benefits to residents of nearby jurisdictions, the cost may depend on the size of nearby jurisdictions. The congestible public good, g_i, is produced from the private good x_i with the cost function

$$c_i^g(g_i, \underbrace{n_i, \mathbf{n}_{-i}}_{\mathbf{n}})$$

where $\mathbf{n}_{-i} = (n_1, \ldots, n_{i-1}, n_{i+1}, \ldots, n_M)$ is the vector of population of all jurisdictions but i. The cost c_i^g is an increasing function of both the level of the public service and the populations of the jurisdictions. As the public good provided in i is consumed not only by the residents i but also by non-residents, congestion is induced by both residents ($\partial c_i^g/\partial n_i > 0$) and non residents ($\partial c_i^g/\partial n_j > 0,\ j \neq i$). The rationale behind this is that non-residents can be viewed as commuting to the jurisdiction i to consume g_i so that providing a given amount of g_i becomes more costly when other jurisdictions are more populated. At one extreme, we have a pure public good, $c_i(g_i, \mathbf{n}) = c_i\left(g_i\right)$, and at the other extreme, a publicly-provided public service, $c(g_i, \mathbf{n}) = c_i\left(g_i\right) \sum_j n_j$.

Similarly, the business public service is also produced from the private good x_i with costs a function of both the level of public investment and the jurisdiction labor force:

$$c_i^b(z_i, \underbrace{L_i, \mathbf{L}_{-i}}_{\mathbf{L}})$$

where $\mathbf{L}_{-i} = (L_1, \ldots, L_{i-1}, L_{i+1}, \ldots, L_M)$ is the vector of labor force of all jurisdictions but i. As with the public consumption good, at one extreme we have a pure good, $c_i^b\left(z_i, \mathbf{L}\right) = c_i^b\left(z_i\right)$ and at the other extrement, a public-provided investment, $c_i^b\left(z_i, \mathbf{L}\right) = c_i^b(z_i) \sum_j L_j$. For convenience, we denote:

$$c_i = c_i(g_i, z_i, \mathbf{n}, \mathbf{L}) = c_i^g(g_i, \mathbf{n}) + c_i^b(z_i, \mathbf{L}) \tag{13}$$

the total public cost function of jurisdiciton i

We define the federal public good and business public service analogously, though note that we allow for the amount provided of each by the federal government to potentially vary among jurisdictions. This variation in federal public services across states reflects the possibility that federal projects are often specific to certain regions and localities, perhaps for the purposes of economic development. Then the costs of providing services of g_i^F to jurisdiction i are

$$c_i^{g_F}(g_i^F, \underbrace{n_i, \mathbf{n}_{-i}}_{\mathbf{n}}),$$

with the cost of providing business public service z_i^F to jurisdiction i given by

$$c_i^{z_F}(z_i, \underbrace{L_i, \mathbf{L}_{-i}}_{\mathbf{L}}).$$

The total federal cost function is the sum of the public good and input costs over all jurisdictions,

$$c^F = \sum_{j=1}^{M} \left[c_i^{g_F}(g_i^F, n_i, \mathbf{n}_{-i}) + c_i^{z_F}(z_i, L_i, \mathbf{L}_{-i}) \right].$$

2.4 Government Budgets

Large debt and deficits are a common feature of many governments meaning that policies are often not budget neutral in the short run; this is also true at the state and local level even when governments have balanced budget requirements, as these requirements are relatively weak. Thus, as in Hendren (2016), we assume that jurisdiction i's budget is unbalanced. A jurisdiction's budget deficit is:

$$\Delta_i = c(g_i, z_i, \mathbf{n}, \mathbf{L}) - n_i(t_i^\ell w_i \ell_i + t_i^h p_i h_i + t_i^x x_i + t_i^n) \tag{14}$$

For notational simplicity, the budget deficit can alo be written as:

$$\Delta_i = c(g_i, z_i, \mathbf{n}, \mathbf{L}) - n_i \sum_{z=\ell,x,h,n} t_i^b \mathrm{B}_i^b = c(g_i, z_i, \mathbf{n}, \mathbf{L}) - n_i r_i \tag{15}$$

where z indexes each base:

$$\mathrm{B}_i^\ell = w_i \ell_i \qquad \mathrm{B}_i^h = p_i h_i \qquad \mathrm{B}_i^x = x_i \qquad \mathrm{B}_i^n = 1, \tag{16}$$

are the per capita tax bases and:

$$r_i = \sum_{z=\ell,h,x,n} t_i^b \mathrm{B}_i^b, \tag{17}$$

is the per capita tax revenue.

2.5 Location choice

In our model, one important theme household mobility, which has been argued to be critical at the state and local level. In particular, a large literature shows that individuals are mobile in response to taxes (Kleven et al., 2020), welfare programs (Brueckner, 2000; Agersnap et al., 2020), and education programs (Epple et al., 2014).

In line with Kline and Moretti (2014), Suárez Serrato and Zidar (2016) and many others, we model household mobility by assuming that e_i is i.i.d. according to the following Gumbel distribution $F(z) = P(e_i \leq z) = e^{-e^{-\left(\frac{z}{\mu}+\gamma\right)}}$ where γ is the Euler's constant ($\gamma \approx 0.5772$) and μ is a positive constant which governs the variance of e_i which is equal to $\pi^2/(6\mu^2)$. The interpretation of parameter μ is provided below.[1] Discrete choice theory allows to derive the probability that a household choose to reside in jurisdiction i:

$$P\left[V_i + e_i = \max_{j=1,\ldots,M}(V_j + e_j)\right] = \frac{\exp(\mu V_i)}{\sum_{j=1}^{M}\exp(\mu V_j)}$$

Then, the number of households choosing to live in jurisdiction i is:

$$n_i = \frac{\exp(\mu V_i)}{\sum_{j=1}^{M}\exp(\mu V_j)}N \tag{18}$$

Notice that this expression guarantees that the population constraint holds $\sum_{i=1}^{n} n_i = N$.

Parameter μ measures the degree of inter-jurisdictional mobility of the households. First, if $\mu \to 0$, equation (18) indicates that households are immobile and all jurisdictions are inhabited by N/m residents. Second, if $\mu \to \infty$, then the variance of the idiosyncratic parameter, e_i, goes to zero. All households are identical so that they all prefer to live in the jurisdiction which provides the highest level of utility. Household mobility is costless as in Roback (1982).

[1] Alternatively, assuming that e_i follows a Fréchet distribution as in Ahlfeldt et al. (2015) would not alter our results. Intuitively, e_i will enter the utility in multiplicative form. Roughly speaking, the exponential is simply replaced by a power function and results of our comparative statics exercise would be identical in signs. In terms of empirical applicability, both distributions are used in the literature.

2.6 General equilibrium

Before proceeding, notice that inserting the profit functions $\pi_i(w_i)$ defined in (2.2) into the Marshallian demands and supplies (6) and into the indirect utility (7), we can write:

$$x_i(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}), \qquad h_i(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}), \qquad \ell_i(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}), \tag{19}$$

and:

$$V_i + e_i = V(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}) + e_i,$$

where $\mathbf{w} = (w_1, \ldots, w_M)$ is the vector of wages of all jurisdictions of the economy. These functions highlight that the Marshallian demands and supplies and the indirect utility are functions of the local housing rent, the wages of all jurisdictions, the local taxes and the public goods of all jurisdictions.

The housing market equilibrium in jurisdiction i is:

$$n_i h_i(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}) = H_i(p_i), \tag{20}$$

which characterizes the level housing rent p_i.

The labor market equilibrium in jurisdiction i is:

$$n_i \ell_i(p_i, \mathbf{w}, \mathbf{t}_i, \mathbf{g}) = L_i(w_i, \mathbf{z}), \tag{21}$$

which characterizes the level of the wage w_i.

The $3m$ equilibrium conditions for each jurisdiction, (18), (20) and (21) implicitly define the levels of the M populations n_i, the M housing rents p_i and the M wages w_i as a function of the M jurisdictions full vector of policies. Following Hendren (2016), define the policy instrument set:

$$P_i = \left\{ t_i^x, t_i^\ell, t_i^h, t_i^n, g_i, z_i. \right\}$$

Inserting the housing rent and wage equilibrium functions into the Marshallian demand and supply functions (19), it follows that the equilibrium local consumption x_i, individual housing consumption h_i and individual labor supply ℓ_i is also a direct function of the policy instrument set P_i. As variables in jurisdiction i also respond to policy changes in the policy set of all other jurisdiction P_j, $j \neq i$, we can write these functions as $n_i(\mathbf{P})$, $p_i(\mathbf{P})$, $w_i(\mathbf{P})$, $x_i(\mathbf{P})$, $h_i(\mathbf{P})$ and $\ell_i(\mathbf{P})$, where

$$\mathbf{P} = (P_1, \ldots, P_M),$$

is the aggregate policy instrument set of all jurisdictions in the economy. We also introduce the following notation:

$$\mathbf{P}_{-i} = (P_1, \ldots, P_{i-1}, P_{i+1}, P_M),$$

which is the aggregate policy instrument set of all jurisdictions except for jurisdiction i, so that for each i, we have: $\mathbf{P} = (P_i, \mathbf{P}_{-i})$.

3 Welfare and budget deficit change

This section derives basic comparative statics results to assess the effect of marginal policy changes on the indirect utility of a resident and on the budget deficit of a government. The focus on marginal policy changes allows us to apply the envelope theorem, simplifying the MVPF. However, many policy changes are large, but some modifications are necessary as discussed in Hendren and Sprung-Keyser (2020) and Kleven (2021). But, our continued focus on small reforms allows us to focus on the key additional parameters necessary when estimating the welfare effects of policies in an open economy.

3.1 Jurisdiction welfare

3.1.1 Local marginal welfare (LMW)

Given that all endogenous variables depend on the policy instrument set, $\mathbf{P}$, we can denote the deterministic part of indirect utility (7) as:

$$V_i(\mathbf{P}) = U\left(\frac{1}{(1+t_i^x)}\left[y(\mathbf{P}) + (1-t_i^\ell)w_i(\mathbf{P})\ell_i(\mathbf{P}) - (1+t_i^h)p_i(\mathbf{P})h_i(\mathbf{P}) - t_i^n\right], h_i(\mathbf{P}), \ell_i(\mathbf{P}), g_i, \mathbf{g}_{-i}\right) \tag{22}$$

where:

$$y_i(\mathbf{P}) = \eta_i + \theta \sum_k \left(\pi_k^x(w_k(\mathbf{P}), \mathbf{z}) + \pi_k^h(p_k(\mathbf{P}))\right)$$

is the equilibrium level of the non-labor income. Then, for any policy instrument $\tau \in \mathbf{P}$, we have

$$\frac{\partial y}{\partial \tau} \equiv \theta \sum_k \left(\frac{\partial \pi_k^x}{\partial w_k} \frac{\partial w_k}{\partial \tau} + \frac{\partial \pi_k^h}{\partial p_k} \frac{\partial p_k}{\partial \tau} \right) \tag{23}$$

which represents the effects of the policy changes on the profits of firms owned by a resident of jurisdiction i. Differentiating V_i with respect to y gives the marginal utility of income:

$$\lambda_i \equiv \frac{\partial V_i}{\partial y} = \frac{1}{1+t_i^x} \frac{\partial U_i}{\partial x_i}, \tag{24}$$

that is, one additional unit given to the resident of jurisdiction i allows her to consume $1/(1+t_i^x)$ units of the numéraire good and thus increases her utility by $1/(1+t_i^x) \times \partial U_i / \partial x_i$ units.

As jurisdiction i is composed of n_i identical individuals we can express marginal welfare in jurisdiction i simply as

$$LMW_{\tau_i} \equiv \frac{n_i}{\lambda_i} \frac{\partial V_i}{\partial \tau_i}. \tag{25}$$

for any policy instrument $\tau_i \in P_i$. We refer to (25) as the "local marginal welfare" (LMW), that is, the welfare change of the infra-marginal residents in the jurisdiction changing its policy. Dividing by the marginal utility of income λ_i defined in (24) expresses the LMW in monetary terms.

Differentiating (22) after applying the envelope theorem, and the fact that the utility of a migrant household is unchanged due to the policy, we obtain for taxes indexed by $z = \ell,\ h,\ x, n$ and for public services/inputs:

$$LMW_{\tau_i} = \text{DE}_{\tau_i} + (1-t_i^\ell) L_i \frac{\partial w_i}{\partial \tau_i} - (1+t_i^h) H_i \frac{\partial p_i}{\partial \tau_i} + n_i \frac{\partial y}{\partial \tau_i} \qquad \tau_i \in P_i \tag{26}$$

with

$$\text{DE}_{t_i^b} = -n_i \text{B}_i^b, \qquad \text{DE}_{g_i} = \frac{n_i}{\lambda_i} \frac{\partial U_i}{\partial g_i}, \qquad \text{DE}_{z_i} = n_i \theta \sum_k \frac{\partial \pi_k^x}{\partial z_i} \tag{27}$$

where $n_i\theta$ is the share of profit generated in jurisdiction k owned by the residents of jurisdiction i, the per capita tax base B_i^b are as defined in (16).

Condition (26) indicates that the effect of a marginal increase in the local tax t_i^b on welfare W_i of residents includes three sub-effects, only the first of which is directly derived in Hendren (2016):

1. **direct effect on willingness-to-pay**: $-n_i \text{B}_i^b$ is a negative effect on willingness to pay from increasing t_i^b.

2. **general equilibrium effects on willingness to pay**: $(1-t_i^\ell)L_i\frac{\partial w_i}{\partial t_i^b} - (1+t_i^h)H_i\frac{\partial p_i}{\partial t_i^b}$ is an ambiguously signed effect on willingness to pay resulting from the impact of the tax on disposable income $(1-t_i^\ell)w_iL_i - (1+t_i^h)p_iH_i$ due to price (wage and housing rent) changes. It is not present in Hendren (2016), who assumes exogenous prices.

3. **effect on profits received by residents**: $-n_i\dfrac{\partial y}{\partial t_i^b}$. This effect, also not in Hendren (2016) is the effect of the policy on the return to assets (profits) of residents of the jurisdiction. If ownership is entirely absentee, that is, completely outside of the economy, then this term is zero.

As changes in the level of public services may change the labor and housing choices of residents ($\partial h_i/\partial g_i \neq 0$, $\partial \ell_i/\partial g_i \neq 0$) and lead the migration to or from the jurisdiction ($\partial n_i/\partial g_i \neq 0$), wages and prices in the jurisdiction will change ($\partial w_i/\partial g_i \neq 0$, $\partial p_i/\partial g_i \neq 0$). Changes in wages will, in turn, affect profits in the jurisdiction as well as possibly other jurisdictions $\left(\theta_{g_i}^i \neq 0\right)$.

3.1.2 External Marginal Welfare (EMW)

While changes in tax rates in one jurisdiction will not have direct effects on welfare of residents of other jurisdictions, migration of individuals among jurisdictions will result in changes in prices in these other jurisdictions thereby changing welfare there. In contrast, public services provided in a jurisdiction have a direct spillover benefits to other jurisdictions in addition to the indirect effects via mobility. We can express marginal welfare in jurisdiction j as:

$$EMW_{\tau_i}^j \equiv \frac{n_j}{\lambda_j}\frac{\partial V_j}{\partial \tau_i}. \tag{28}$$

Differentiating the welfare of the residents in jurisdiction j (W_i) with respect to another jurisdiction i's policy instruments, we obtain for $\tau_i \in P_i$:

$$EMW_{\tau_i}^j = \text{DE}_{\tau_i}^j + (1-t_j^\ell)L_j\frac{\partial w_j}{\partial \tau_i} - (1+t_j^h)H_j\frac{\partial p_j}{\partial \tau_i} + n_j\frac{\partial y}{\partial \tau_i}, \tag{29}$$

where

$$\text{DE}^j_{t_i^b} = 0 \qquad \text{DE}^j_{g_i} = \frac{n_j}{\lambda_j}\frac{\partial U_j}{\partial g_i} \qquad \text{DE}^j_{z_i} = n_j \theta \sum_k \frac{\partial \pi^x_k}{\partial z_i} \tag{30}$$

The effect on the indirect utility V_j of all tax changes in another jurisdiction i reduces to the mobility effect. However, due to public good spillovers, a change in another jurisdiction public good provision also has a direct effect, $\text{DE}^j_{g_i}$

Equation (29) gives the effect of a change in a single jurisdiction's policy on the welfare of residents in another jurisdiction, an externality of the policy. In some circumstances, this externality may influence jurisdictions that are very far away. Thus, to fully capture the externalities requires knowing the effects of the policy on all jurisdictions other than the one enacting the policy. Let this be denoted by $EMW_{t_i^x} \equiv \sum_{j\neq i} EMW^j_{t_i^b} + \sum_{j\neq i} \frac{n_j}{\lambda_j}\frac{\partial V_j}{\partial g_i}$. Although knowing the total external effect of a policy may involve knowing the external effect on many jurisdictions, for many policies, we might have information that the spillovers or localized to contiguous neighbors. For other policies, we may not know the external effect on every individual jurisdiction, but we may have estimates of the commutative effect, which will be necessary for welfare analysis.

3.2 Jurisdiction budget deficit

3.2.1 Local Marginal Deficit (LMD)

We can denote the budget deficit (15) as follows:

$$\Delta_i(\mathbf{P}) = c(g_i, z_i, \mathbf{n}(\mathbf{P}), \mathbf{L}(\mathbf{P})) - n_i(\mathbf{P})\mathbf{t}_i\mathbf{q}_i(\mathbf{P})\mathbf{x}_i(\mathbf{P}). \tag{31}$$

where we have introduced the following vector notations: $\mathbf{t}'_i = (t^\ell_i \;\; t^h_i \;\; t^x_i \;\; t^n_i)$, $\mathbf{q}'_i = (w_i \;\; p_i \;\; 1 \;\; 1)$ and $\mathbf{x}'_i = (\ell_i \;\; h_i \;\; x_i \;\; 1)$. Differentiating (31), we obtain the "local marginal deficit" (LMD), for government spending and taxes $z = \ell, h, n, x$:

$$LMD_{\tau_i} = \text{ME}_{\tau_i} - n_i\left(\mathbf{t}_i\mathbf{q}_i\frac{\partial \mathbf{x}_i}{\partial \tau_i} + \mathbf{t}_i\mathbf{x}_i\frac{\partial \mathbf{q}_i}{\partial \tau_i}\right) + \left(\frac{\partial c_i}{\partial \mathbf{n}}\frac{\partial \mathbf{n}}{\partial \tau_i} - r_i\frac{\partial n_i}{\partial \tau_i}\right) + \frac{\partial c_i}{\partial \mathbf{L}}\frac{\partial \mathbf{L}}{\partial \tau_i} \tag{32}$$

where

$$\text{ME}_{t_i^b} = -n_i \text{B}^b_i \qquad \text{ME}_{g_i} = \frac{\partial c_i}{\partial g_i} \qquad \text{ME}_{z_i} = \frac{\partial c_i}{\partial z_i} \tag{33}$$

where $\partial \mathbf{v}/\partial y$ denotes the gradient of any vector function $\mathbf{v}$ with respect to any variable y, and $\partial f/\partial \mathbf{x}$ denotes the jacobian of any scalar function f with respect to any vector $\mathbf{x}$. Condition (32) indicates that the effect on the budget deficit of a marginal increase in the tax t_i^b can be decomposed in three effects.

1. **a mechanical effect**: $-n_i \mathrm{B}_i^b$ is the negative effect of a tax increase on the budget deficit. This is present in Hendren (2016).

2. **behavioral and price (wage) effects**:

   (a) **Behavorial effects:**[2]

   $$-n_i \mathbf{t}_i \mathbf{q}_i \frac{\partial \mathbf{x}_i}{\partial t_i^b} = -n_i \left(t_i^x \frac{\partial x_i}{\partial t_i^b} + t_i^\ell w_i \frac{\partial \ell_i}{\partial t_i^b} + t_i^h p_i \frac{\partial h_i}{\partial t_i^b} \right)$$

   These are the effects on consumption (supply) of the three tax goods $(x_i, \ell_i,\, h_i)$ from the change in tax t_i^b increase absent changes in wages and prices.[3] This effect is present in Hendren (2016).

   (b) **Indirect price (or wage) effects:**

   $$-n_i \mathbf{t}_i \mathbf{x}_i \frac{\partial \mathbf{q}_i}{\partial t_i^b} = -n_i \left(t_i^\ell \ell_i \frac{\partial w_i}{\partial t_i^b} + t_i^h h_i \frac{\partial p_i}{\partial t_i^b} \right)$$

   These effects result from the nature of the taxes which are ad valorem. Thus, changes in the wage rate will change the tax base for the labor tax t_i^ℓ and changes in the price of housing affect the base for the property tax t_i^h. These effects are not in Hendren (2016) which assumes exogenous price and wages.

3. **a mobility effect**:

   $$\frac{\partial c_i}{\partial \mathbf{n}} \frac{\partial \mathbf{n}}{\partial t_i^b} - r_i \frac{\partial n_i}{\partial t_i^b} = \sum_k \frac{\partial c_i}{\partial n_k} \frac{\partial n_k}{\partial t_i^b} - r_i \frac{\partial n_i}{\partial t_i^b}$$

   is due to the effect of changes in t_i^b on flows of households into [out of] jurisdiction i. This alters the cost of public services and all of the tax bases. Population changes in other jurisdictions also alters the cost of local goods due to spillovers of the congestible good.

[2] Notice that for convenience, and with a slight abuse in mathematical notation, we denote for any three vectors $\mathbf{v} = (v_1\, v_2\, \ldots)$, $\mathbf{w} = (w_1\, w_2\, \ldots)$ and $\mathbf{x} = (x_1\, x_2\, \ldots)$ with identical length: $\mathbf{vwx} = \sum_k v_k w_k x_k$, which extends the concept of dot product to three vectors.

[3] The head tax is independent of consumption levels. This is why it does not appear here.

4. **a congestion effect**:

$$\frac{\partial c_i}{\partial \mathbf{L}}\frac{\partial \mathbf{L}}{\partial t_i^b} = \sum_k \frac{\partial c_i}{\partial n_k}\frac{\partial L_k}{\partial t_i^b}$$

which is related to business public service provision. It results from changes in employment $L_k = n_k \ell_k$ in each jurisdictions k. This congestion effect is not a pure mobility effect. It includes both a mobility effect (change in the population n_k) and an intensive-margin effect (change in the individual labor supply ℓ_k).

The effects of an increase in the public service on the budget deficit, (31), are analogous to those for the taxes described above.

3.2.2 External Marginal Deficit (EMD)

Finally, when other governments change their policies, these policy changes have spillover effects that impose fiscal externalities on jurisdiction i.

$$EMD_{\tau_i}^j \equiv \frac{\partial \Delta_j}{\partial \tau_i}$$

The effect of other jurisdictions' policy instruments on jurisdiction j's budget is, for $\tau_i \in P_i$:

$$EMD_{\tau_i}^j = -n_j\left(\mathbf{t}_j\mathbf{q}_j\frac{\partial \mathbf{x}_j}{\partial \tau_i} + \mathbf{t}_j\mathbf{x}_j\frac{\partial \mathbf{q}_j}{\partial \tau_i}\right) + \left(\frac{\partial c_j}{\partial \mathbf{n}}\frac{\partial \mathbf{n}}{\partial \tau_i} - r_j\frac{\partial n_j}{\partial \tau_i}\right) + \frac{\partial c_j}{\partial \mathbf{L}}\frac{\partial \mathbf{L}}{\partial \tau_i},$$

which involves all the effects described above except the mechanical effect. These effects are zero in Hendren (2016) which considers a single closed jurisdiction. Intuitively, the effect of policies in one jurisdiction result in mobility to or from other jurisdictions, changing prices in those jurisdictions. Moreover, because business public services and goods are congestible, the population of one jurisdiction influences the cost of other jurisdictions.[4]

4 Marginal Value of Public Funds (MVPF)

This section derives the MVPF in a federation featuring spillovers and mobility. Section 4.1 derives the expression of local MVPFs, that is, the MVPF facing a single jurisdiction. Section 4.2 derives the expressions of related social MVPFs, that is, the MVPF facing a federal planner.

[4] For example, an increase in a tax in jurisdiction i will in general spur residents to locate other jurisdictions j so that their population n_j and workforce $L_j = n_j \ell_j$ will increase, thus increasing their congestion costs.

4.1 Local and external MVPF

We next proceed by deriving the marginal value of public funds. Here we define the marginal value of public funds as the MVPF for a policy change by a single jurisdiction i. Because individuals receive utility from the policies of other jurisdictions, a policy change in jurisdiction i may also affect the MVPF of other nearby jurisdictions. The former of these is the **local MVPF**, while the latter is the **external MVPF**. The external MVPF is the marginal value of public funds for jurisdictions affects by a policy change elsewhere. Given the presence of spillovers, denote $LMVPF_i^{\tau}$ as the local MVPF for jurisdiction i following its own policy change and let $LMVPF_j^{\tau}$ be the external MVPF due to spillovers.

4.1.1 Local MVPFs

As a local planner cares only about the well being of its residents and the cost to its budget, a local planner will not internalize any of the spillover or mobility effects on other jurisdictions. The Local Marginal Value of Public Funds (LMVPF) in jurisdiction i has a similar form to the prior literature, but the components of the LMVPF will include additional terms:[5] $LMVPF_{\tau_i} = LMW_{\tau_i}/LMD_{\tau_i}$ for all $\tau_i \in P_i$. We can now proceed to see how each of the general parts of the LMVPF are affected by mobility and spillovers and how these effects are missing from the prior literature. Using the expressions derived in section 3, the local MVPFs with respect to tax instrument t_i^b, $z = l, n, x$ are:

$$LMVPF_{\tau_i} = \frac{\mathrm{DE}_{\tau_i} + (1-t_i^{\ell})L_i\dfrac{\partial w_i}{\partial \tau_i} - (1+t_i^h)H_i\dfrac{\partial p_i}{\partial \tau_i} + n_i\dfrac{\partial y}{\partial \tau_i}}{\mathrm{ME}_{\tau_i} - n_i\left(\mathbf{t}_i\mathbf{q}_i\dfrac{\partial \mathbf{x}_i}{\partial \tau_i} + \mathbf{t}_i\mathbf{x}_i\dfrac{\partial \mathbf{q}_i}{\partial \tau_i}\right) + \left(\dfrac{\partial c_i}{\partial \mathbf{n}}\dfrac{\partial \mathbf{n}}{\partial \tau_i} - r_i\dfrac{\partial n_i}{\partial \tau_i}\right) + \dfrac{\partial c_i}{\partial \mathbf{L}}\dfrac{\partial \mathbf{L}}{\partial \tau_i}}, \tag{34}$$

where:

$$\mathrm{DE}_{t_i^b} = -n_i\mathrm{B}_i^b, \qquad \mathrm{DE}_{g_i} = \frac{n_i}{\lambda_i}\frac{\partial U_i}{\partial g_i}, \qquad \mathrm{DE}_{z_i} = n_i\theta\sum_k \frac{\partial \pi_k^x}{\partial z_i} \tag{35}$$

$$\mathrm{ME}_{t_i^b} = -n_i\mathrm{B}_i^b \qquad \mathrm{ME}_{g_i} = \frac{\partial c_i}{\partial g_i} \qquad \mathrm{ME}_{z_i} = \frac{\partial c_i}{\partial z_i} \tag{36}$$

and recall from (14) that $r_i = t_i^{\ell}w_i\ell_i + t_i^h p_i h_i + t_i^x x_i + t_i^n$ and from (16) that $\mathrm{B}_i^{\ell} = w_i\ell_i$, $\mathrm{B}_i^h = p_i h_i$, $\mathrm{B}_i^x = x_i$ and $\mathrm{B}_i^n = 1$.

In the extreme case where population is immobile, wages and housing rents are constant, and

[5] This coincides with the definition in equation (13) in Hendren (2016).

labor entails no congestion in the provision of the business public service, the LMVPF (34) becomes:

$$LMVPF_{\tau_i} = \frac{\text{DE}_{\tau_i}}{\text{ME}_{\tau_i} - n_i \mathbf{t}_i \mathbf{q}_i \dfrac{\partial \mathbf{x}_i}{\partial \tau_i}},$$

which is identical to that in Hendren (2016). For example, the LMVPF for a the marginal increase in the head tax discussed at length in Finkelstein and Hendren (2020) (34) becomes:

$$LMVPF_{t_i^n} = \frac{1}{1 + FE_i}.$$

where

$$FE_i = t_i^x \frac{\partial x_i}{\partial t_i^n} + t_i^h p_i \frac{\partial h_i}{\partial t_i^n} + t_i^\ell w_i \frac{\partial \ell_i}{\partial t_i^\ell}$$

In words, the MVPF is one over the mechanical effect plus the behavioral effect – or one over one plus the fiscal externality. We will subsequently discuss the interpretation when people are mobile, prices are not constant, and there are congestion costs.

4.1.2 External MVPFs

As noted previously, policy change in any one jurisdiction will have budgetary effects in other jurisdictions. Moreover, because of the presence of expenditure spillovers, individuals in other jurisdictions will have a positive willingness to pay for increases in public services elsewhere. This leads to external MVPFs: $EMVPF^j_{\tau_i} = EMW^j_{\tau_i}/EMD^j_{\tau_i}$ for all $\tau_i \in P_i$. Using the expressions derived in section 3, we have the following cross-effect local MVPFs:

$$EMVPF^j_{\tau_i} = \frac{\text{DE}^j_{\tau_i} + (1 - t_j^\ell) L_j \dfrac{\partial w_j}{\partial \tau_i} - (1 + t_j^h) H_j \dfrac{\partial p_j}{\partial \tau_i} + n_j \dfrac{\partial y}{\partial \tau_i}}{-n_j \left(\mathbf{t}_j \mathbf{q}_j \dfrac{\partial \mathbf{x}_j}{\partial \tau_i} + \mathbf{t}_j \mathbf{x}_j \dfrac{\partial \mathbf{q}_j}{\partial \tau_i} \right) + \left(\dfrac{\partial c_j}{\partial \mathbf{n}} \dfrac{\partial \mathbf{n}}{\partial \tau_i} - r_j \dfrac{\partial n_j}{\partial \tau_i} \right) + \dfrac{\partial c_j}{\partial \mathbf{L}} \dfrac{\partial \mathbf{L}}{\partial \tau_i}}, \tag{37}$$

where

$$\text{DE}^j_{t_i^b} = 0 \qquad \text{DE}^j_{g_i} = \frac{n_j}{\lambda_j} \frac{\partial U_j}{\partial g_i} \qquad \text{DE}^j_{z_i} = n_j \theta \sum_k \frac{\partial \pi_k^x}{\partial z_i} \tag{38}$$

In Hendren (2016), the external MVPF is assumed to be zero because he considers a single jurisdiction. While these external spillovers might have limited use for policymaking in their own right, as will become clear, they will be critical for a federal planner who internalizes spillovers and interjurisdictional fiscal externalities. These spillovers have been shown to be empirically important (Etzel et al., 2021).

4.2 Social MVPF

Because we consider a multiple jurisdiction framework, the MVPF of a local government will not internalize interjurisdictional externalities, while a federal planner will account for these spillovers. Therefore, one may be interested in considering the overall effect of policy changes on the entire federal economy and then comparing this to the local MVPF. The federal planner's social welfare function is a weighted sum of utilities over all states in the federation given by:

$$W = \sum_{i=1}^{M} \psi_i n_i V_i$$

where ψ_i, $i = 1, \ldots, M$ are social weights. A federal planner accounts for interjurisdictional spillovers and fiscal externalities when determining the optimal policy. The aggregate deficit of the federation is:

$$\Delta = \sum_{i=1}^{M} \Delta_i$$

We define the federal planner's MVPF as the social MVPF as:

$$SMVPF_{\tau_i} \equiv \frac{\psi_i LMW_{\tau_i} + \sum_{\substack{j=1 \\ j \neq i}}^{M} \psi_j EMW_{\tau_i}^{j}}{LMD_{\tau_i} + \sum_{\substack{j=1 \\ j \neq i}}^{M} EMD_{\tau_i}^{j}} \tag{39}$$

This expression makes clear that if jurisdictions are symmetric, the social MVPF (39) is equal to the local MVPF (34). Moreover, the social MVPF is defined as the separate aggregation of the numerators [denominators] of all local MVPFs. The social MVPF is not the aggregation or average of all local MVPFs, but rather is the separate aggregation of the willingness to pay and the cost on the government budget. Intuitively, this is because the planner cares about the weighted sum of willingness to pay and the net cost to the government.

4.3 MVPF Measures and Price Effects

A standard practice in benefit-cost analysis, in the terms we use above, is to only consider the direct effect and ignore any effects on wages and prices, "pecuniary" benefits and costs absent any distortions in prices. The rationale for doing so rests on the assumption that the welfare of buyers and sellers or the welfare of consumers and firm owners are weighted equally. Then, for example, the benefits to laborers of a wage increase as a result of policy is entirely offset by the loss in profits to firm owners.

The open economy nature of our analysis complicates the treatment of these pecuniary effects. These complications arise for two reasons: first, different welfare weights across jurisdictions and second, external ownership (to the jurisdiction) of firms and housing. In our setting, then, price and wage effects will not appear in either the LMW or the SMW if there is local ownership of firms and the housing (land) stock, that is, all profits stay in the jurisdiction and the welfare weights are equal across jurisdictions. Alternatively, if there is external ownership of profits, price and wage effects will appear in the LMW: increases [decreases] in employee wages are not fully offset by decreases [increases] in local profits. However, with equal welfare weights, again, price and wage effects do not appear in the SMW.

Then, in the general case of some external ownership of firms and housing along with unequal welfare weights across jurisdictions, price and wage effects will appear in both the LMW and SMW. Changes in prices and wages affect tax revenues directly for ad valorem taxes and indirectly through behavioral changes affecting the tax base. Then price and wage changes will appear in the denominators of the LMVPF and SMVPF, that is, the LMD and the SMD.

A related concern that arises in benefit-cost analysis is of "double counting." The following is an example of this from an popular intermediate public economics text (Rosen and Gayer, 2014). As a result of an increase in its future stream of income, the land value of a farm also increases. Including both the income and land value as benefits, then, is double-counting. In our measure of LMW, this double counting will not occur if all profits are local – the farmer is both the renter of his or her land as well as the owner, so that the net effect of the increase in land value in LMW is zero. However, if the farmer is renting land owned by an absentee landowner living outside the jurisdiction, then the LMW includes both the farmer's income stream and the cost of an increase in rent to him. As LMW measures the effect of a policy on local utility, it needs to include both the direct effect (income stream) and the effects of the associated price changes on utility. The increase in land value (rent) received by the landowner is in the EMW. With equal weights on welfare, as discussed, the price effects will cancel in the SMW.

4.3.1 MVPF with Atomistic Jurisdictions

Much of the literature in state and local public economics assumes atomistic jurisdictions, that is, jurisdictions that are a negligible share of the federation's population. While our model includes this case, our model also allows for non-atomistic jurisdictions, that is, jurisdictions that have a non-negligible share of population and tax base. However, given the popularity of atomistic jurisdictions in modeling local policies and its relevance for many policies such as capital taxation—where no one jurisdiction can reasonably affect the world rate of return to capital—it is worth briefly discussing this special case. These atomistic jurisdictions are "utility takers", meaning that any increases [decreases] in utility directly due to a policy change (the direct effect) are entirely offset by increases [decreases] in consumer prices (i.e., housing) or decreases [increases] in wages. In this case, the direct effects of any change in local policy on local resident utility are entirely offset by the associated price changes, meaning that LMW is equal to zero.

However, while the LMW approaches zero as the size of the jurisdiction approaches zero, the sum of EMW and, therefore, SMW does not. To see this consider a simple example of M identical jurisdictions each providing a public good g_j with rent of p_j per fixed lot. Let the rents (profits) in all jurisdictions be shared equally within the federation, an assumption we return to later. Then let jurisdiction i increase its public good. Doing so increases rent there by $\partial p_i/\partial g_i = (1 - 1/M)\,\text{DE}^i_{g_i}$ and decreases rent in each of the other $M-1$ jurisdictions by $\frac{\partial p_j}{\partial g_i} = \frac{1}{M}\text{DE}^i_{g_i}$, $j \neq i$, where $\text{DE}^i_{g_i}$ is the direct benefit from the increase in g_i. Then as the number of jurisdictions becomes large ($M \to \infty$) the direct effect of the increase in g_i on utility is entirely offset by effect of the price increase. However, while in the limit, EMW approaches zero ($\lim_{M\to\infty} EMW = -\partial p_j/\partial g_i = 0,\ j \neq 1$) the sum of the EMW, $(M-1)\partial p_j/\partial g_i$, converges to $\text{DE}^i_{g_i}$.

While it may seem counter-intuitive that any jurisdiction would want to provide public goods if they have no affect on the utility of their residents, this outcome hinges on the assumption that all residents are renters, not homeowners. If rents are all locally-owned (homeowners) then resident utility increases as a result the increase in their incomes making $LMW = \text{DE}^i_{g_i}$ and $EMW = 0$ with SMW remaining equal to $\text{DE}^i_{g_i}$.

4.4 Comparison of the different MVPFs

A central claim of our paper is that the MVPF requires a special care when applied to a federation. In a federal context, not accounting for interjurisdiction effects in the MVPF might might result in mismeasurement of the MVPF. Moreover, a social planner may have a very different MVPF from a federal planner. This is represented in Table 1.

Table 1. Components of the MVPFs when jurisdiction i increases instrument τ.

	(1) Notation	(2) Description	(3) Formula	(4) MVPF^C	(5) LMVPF	(6) EMVPF	(7) SMVPF	(8) Simulation
A. Numerator	DE_{ij}	Direct effect on WTP	$\text{DE}^j_{\tau_i}$	✓	✓	✓	✓	✓
	W_{ij}	Wage effect on WTP	$(1-t^\ell_j)L_j\dfrac{\partial w_j}{\partial \tau_i}$		✓	✓	✓	✓
	R_{ij}	Rent effect on WTP	$-(1+t^h_j)H_j\dfrac{\partial p_j}{\partial \tau_i}$		✓	✓	✓	✓
	Π_{ij}	Profit effect on WTP	$n_j\dfrac{\partial y}{\partial \tau_i}$		✓	✓	✓	
B. Denominator	ME_{ij}	Mechanical effect	ME_{τ_i}	✓	✓		✓	✓
	B_{ij}	Behavioral effect	$-n_j\mathbf{t}_j\mathbf{q}_j\dfrac{\partial \mathbf{x}_j}{\partial \tau_i}$	✓	✓	✓	✓	✓
	P_{ij}	Price effect	$-n_j\mathbf{t}_j\mathbf{x}_j\dfrac{\partial \mathbf{q}_j}{\partial \tau_i}$		✓	✓	✓	✓
	M_{ij}	Mobility effect	$\dfrac{\partial c_j}{\partial \mathbf{n}}\dfrac{\partial \mathbf{n}}{\partial \tau_i} - r_j\dfrac{\partial n_j}{\partial \tau_i}$		✓	✓	✓	✓
	C_{ij}	business public service congestion	$\dfrac{\partial c_j}{\partial \mathbf{L}}\dfrac{\partial \mathbf{L}}{\partial \tau_i}$		✓	✓	✓	✓

NOTE— "WTP" stands for "willingness to pay". MVPF^C stands for the MVPF expression derived in a closed economy (e.g. Hendren, 2016). The direct effect $\text{DE}^j_{\tau_i}$ is as defined in equations (27) and (30) and the mechanical effect ME_{τ_i} is as defined in equation (33). The profit effects are not checked in the last column because the numerical application in section 4.4 assumes external profit ownership, unlike the rest of the paper which assumes a closed economy.

Table 1 indicates that the MVPF expressions derived for a closed economy (e.g. Hendren, 2016) ignore capitalization and mobility effects. The purpose of the remainder of this subsection is to assess if these missing effects entail significant error for practitioners wishing to use the MVPF to make policy. Why does accounting for inter-jurisdictional mobility and wage/rent capitalization matter in assessing a public policy when using the MVPF as an indicator? Assume that the researcher is able to estimate all the responses $\partial Y/\partial X$ in column 3 of Table 1. How much and in which direction are biases in the estimates of the MVPFs when based on causal effects excluding mobility and spillovers (column 4) of Table 1 compared to the MVPF estimates accounting for household mobility and capitalization (columns 5 to 7)? A general answer is that these bias could be in any direction depending on the estimated values of the mobility and capitalization responses $\partial n_j/\partial \tau_i$, $\partial w_j/\partial \tau_i$ and $\partial p_j/\partial \tau_i$. However, our numerical application can give a sense of the magnitude and direction of these biases, as well as differentially inform the decisions of local policymakers and federal policymakers.

Before proceeding, one needs to make clear which MVPF formulas must bee assessed and compared. Our baselines are the MVPFs formulas derived in Hendren (2016) which assumes that prices are exogenous and households are immobile. As section 4 makes clear, the MVPF formula is not the same if it is seen from the viewpoint of a single jurisdiction (local MVPF) or if the federation viewpoint is adopted (social MVPF). The MVPF formula derived in Hendren (2016) can easily be applied to both contexts:

$$LMVPF^{\mathrm{C}}_{\tau_i} = \frac{\mathrm{DE}_{ii}}{\mathrm{ME}_{ii} + B_{ii}}, \qquad SMVPF^{\mathrm{C}}_{\tau_i} = \frac{\sum_{j=1}^{M} \psi_j \mathrm{DE}_{ij}}{\mathrm{ME}_{ii} + \sum_{j=1}^{M} B_{ij}}, \tag{40}$$

where parameters ψ_j, $j = 1, \dots, M$ are the social weights introduced in section 4.2. As recalled in Table 1, these MVPF expressions include direct effects, DE_{ij}, on the willingness to pay for public policy, a mechanical effect, ME_{ii}, and behavioral effects, B_{ij}, both affecting on the budget deficit.

While it is straightforward to extend the MVPF formula in Hendren (2016) from local (LMVPF) to social (SMVPF), the only reason which empirical estimates of these two measure would differ is inter-jurisdictional mobility. Indeed, if households are not mobile as a consequence of jurisdiction i's policy, $\partial n_j/\partial \tau_i = 0$, there is no capitalization in jurisdiction j, $\partial w_j/\partial \tau_i = \partial p_j/\partial \tau_i = 0$ and thus no effects on consumption and labor supplies of the residents of j, $\partial x_j/\partial \tau_i = \partial h_j/\partial \tau_i = \partial \ell_j/\partial \tau_i = 0$. It follows that $\mathrm{DE}_{ij} = B_{ij} = 0$ for all $j \neq i$ and thus $LMVPF^{\mathrm{C}}_{\tau_i} = SMVPF^{\mathrm{C}}_{\tau_i}$. In other words, using a theoretical model excluding mobility across jurisdictions is not suited to study how a national MVPF if only part of the country is affected by the policy.

However, the empirical researcher might still want to evaluate both $LMVPF^{\mathrm{C}}_{\tau_i}$ and $SMVPF^{\mathrm{C}}_{\tau_i}$. Thus, panels I.A and I.B in Table 5 reports the values of these two indicators for our quantitative model. One can notice that $LMVPF^{\mathrm{C}}_{\tau_i} \approx SMVPF^{\mathrm{C}}_{\tau_i}$ for all policy instruments which is in line with the low cross consumption and labor supply effects in Table 4: $\partial x_2/\partial \tau_1 \approx \partial \ell_2/\partial \tau_1 \approx 0$.[6]

Suppose now that the empirical researcher uses an MVPF formula suited to a federation economy, that is, accounting for inter-jurisdictional mobility and capitalization. As stated in section 4 three different types of MVPFs need to be computed: a local MVPF accounting for the effects of jurisdiction i's policy on jurisdiction i itself, external MVPFs accounting for the effects of jurisdiction i's policy on the other jurisdictions, and the social MVPF accounting for all these effects. The explicit formulas are stated in equations (34), (37) and (39). Using the notations in Table 1, they

[6] Notice however that in Table 4, $\partial h_2/\partial \tau_1$ is relatively high. We plan to further investigates this point.

can be written as:

$$LMVPF_{\tau_i} = \frac{\text{DE}_{ii} + W_{ii} + R_{ii} + \Pi_{ii}}{\text{ME}_{ii} + B_{ii} + P_{ii} + M_{ii} + C_{ii}}, \qquad EMVPF_{\tau_i} = \frac{\text{DE}_{ij} + W_{ij} + R_{ij} + \Pi_{ij}}{B_{ij} + P_{ij} + M_{ij} + C_{ij}}, \tag{41}$$

and:

$$SMVPF_{\tau_i} = \frac{\sum_{j=1}^{M} \psi_j(\text{DE}_{ij} + W_{ij} + R_{ij} + \Pi_{ij})}{\text{ME}_{ii} + \sum_{j=1}^{M}(B_{ij} + P_{ij} + M_{ij} + C_{ij})}, \tag{42}$$

They are assessed for our quantitative application in panel II of Table 5 and the level of the various components are reported in Table 6. Several comments need to be made about these MVPF formulas.

5 Some special cases

To gain intuition into how the MVPF applies in a federation and how local and social MVPF differ, this section considers two special cases. Section 5.1 considers a general two-jurisdiction economy in which individual housing demand and labor supply are fixed, so that policy incidence on housing rents and wages are only due to inter-jurisdictional mobility. Section 5.2 provides numeric simulation of the model for specific functional forms, allowing for elastic individual housing demand and labor supply.

5.1 General 2-jurisdiction model

This section studies how populations and consumption respond to changes in the level of the policy instruments of a given jurisdiction. The purpose is to provide insights into the components of the MVPF. In the fully flexible model introduced in the previous subsections, these responses are by nature ambiguous and depend on model specifications (e.g. different housing supply and production functions) and calibration.

5.1.1 Assumptions

To gain intuition, this subsection (only) focuses on a special case that guarantees meaningful economic responses and is intuitive. Namely, we consider an economy with $M = 2$ jurisdictions. Individuals' labor supply and housing demand are inelastic and equal to one, so that rent and wage variations only results from population changes. We ignore business public services ($\forall i, z_i = 0$) and federal policy instruments, so that the public policy instrument set becomes $P_i = \{t_i^x, t_i^\ell, t_i^h, g_i\}$.

Housing and firms' profits are owned by absentee owners, so that $\partial y/\partial \tau = 0$, for all $\tau \in P_i \cup P_{-i}$. The utility funciton (4) becomes:

$$U_i + e_i = U(x_i, g_i, g_{-i}) + e_i$$

and as $z_i = 0$, $L_i = n_i$, the individual firm's production function (8) becomes:

$$f_i = f_i\left(\frac{n_i}{m_i}, n_i\right)$$

As $n_{-_i} = N - n_i$, the public cost function (13) reduces to a function of the local public good provision g_i and the local population n_i:

$$c_i = c_i(g_i, n_i)$$

5.1.2 Responses of the economy to policy changes

The budget constraint (5) can be written as:

$$x_i = \frac{1}{1+t_i^x}\left[y_i + (1-t_i^\ell)w_i - (1+t_i^h)p_i - t_i^n\right] \tag{43}$$

The housing market equilibrium in jurisdiction i (20) can be written as:

$$n_i = H_i(p_i), \tag{44}$$

which implicitly defines the housing rent p_i as a function of the population. Implicitly differentiating (44), we obtain:

$$\frac{\partial p_i}{\partial n_i} = \frac{1}{H_i'(p_i)} > 0, \tag{45}$$

which indicates that an increase in population, that is an increase in housing demand, exerts an upward pressure on the housing rent. The labor demand in jurisdiction i is implicitly defined by the firm's first-order condition (9) which can be written as:

$$\frac{\partial f_i}{\partial l_i}\left(\frac{n_i(w_i)}{m_i}, n_i(w_i)\right) = w_i \tag{46}$$

The labor market equilibrium in jurisdiction i (21) can be written as:

$$n_i = n_i(w_i) \tag{47}$$

which characterizes the level of the wage w_i. From (46), we have:

$$\frac{\partial w_i}{\partial n_i} = \frac{1}{m_i}\frac{\partial^2 f_i}{\partial l_i^2} + \frac{\partial^2 f_i}{\partial L_i \partial l_i} \quad \equiv \psi \tag{48}$$

which might be positive or negative depending on whether agglomeration economies outweigh decreasing marginal returns or not. We assume that for each $i = 1, 2$ and $j = 1, 2$ with $j \neq i$:[7]

$$(1 - t_i^\ell)\frac{\partial w_i}{\partial n_i} - (1 + t_i^h)\frac{\partial p_i}{\partial n_i} < \frac{N\,(1 + t_i^x)}{2\mu n_i n_j \dfrac{\partial U_i}{\partial x_i}} \tag{49}$$

where $\partial w_i/\partial n_i$ and $\partial p_i/\partial n_i$ are as defined in (45) and (48). Assumption (49) imposes that the disposable income does not increase [decrease] too fast in response to new residents inflows [outflows]. Specifically, it requires that the wage w_i has moderated increase compared to the housing rent p_i. Notice that in cases of strong decreasing marginal products ($\psi < 0$), we have $\mathrm{d}w_i/\mathrm{d}n_i \leq 0$ from (48), so that condition (49) immediately holds since rent is an increasing function of population and the right-hand side of (49) is strictly positive. Thus, this assumption is only necessary in the case of agglomeration economies.

Differentiating (18) with respect to policy instrument $\tau \in \mathbf{P}$, we obtain for each tax $b = n, x, l$ and spending policy:[8]

$$\frac{\partial n_i}{\partial t_i^b} < 0, \qquad\qquad \frac{\partial n_i}{\partial g_i} > 0. \tag{50}$$

As expected, conditions (50) state that an increase in local taxation entails outflows of residents, while an increase in public good provision attracts new residents. The signs of the housing rent and

[7] In the case of household perfect mobility ($\mu \to \infty$), condition (49) reduces to $(1 - t_i^\ell)\dfrac{\partial w_i}{\partial n_i} - (1 + t_i^h)\dfrac{\partial p_i}{\partial n_i} < 0$, which guarantees stability of the location equilibrium. In our model, stability is guaranteed by the idiosyncratic taste of individuals for locations, but condition (49) guarantees economically meaningful responses of population to policy changes.

[8] See Appendix A for detailed derivations.

wage responses follow from (45) and (48) and are, for the set of taxes and spending policies:

$$\frac{\partial p_i}{\partial t_i^b} < 0, \qquad \text{sign}\left(\frac{\partial w_i}{\partial t_i^b}\right) = -\text{sign}(\psi), \tag{51}$$

$$\frac{\partial p_i}{\partial g_i} > 0, \qquad \text{sign}\left(\frac{\partial w_i}{\partial g_i}\right) = \text{sign}(\psi), \tag{52}$$

For example, we know from (50) that a marginal increase in any tax entails outflows of residents. Condition (51) states that this reduction in population reduces housing rents in the jurisdiction because the housing market incurs less pressure. It also states that in the case of strong agglomeration economies [decreasing marginal products] $\psi > 0$ [$\psi < 0$], less population also means a lower [higher] wage.

Next, we turn to the responses of private consumption x_i to policy changes. To gain intuition, consider first the case of a marginal increase in the head tax t_i^n. Differentiating (43), we obtain:

$$\frac{\partial x_i}{\partial t_i^n} = \frac{1}{1+t_i^x}\left(-1 + (1-t_i^\ell)\frac{\partial w_i}{\partial t_i^n} - (1+t_i^h)\frac{\partial p_i}{\partial t_i^n},\right) \tag{53}$$

which indicates that two different effects are at stake. First, an increase in t_i^n reduces the consumption by $-\frac{1}{1+t_i^x}$ units. This is a direct income effect. Second, the tax increase spurs households to reside outside the jurisdiction, which reduces the local housing rent, changes the local wage and thus changes disposable income and consumption by $\frac{1}{1+t_i^x}\left((1-t_i^\ell)\frac{\partial w_i}{\partial t_i^n} - (1+t_i^h)\frac{\partial p_i}{\partial t_i^n}\right)$ units. These two effects are in opposite directions if agglomeration economies are sufficiently weak for the disposable income to increase in response to the population outflow resulting from the tax increase. However, it can be shown that, whatever the degree of agglomeration economies ($\forall\psi \in \mathbb{R}$), we have: [9]

$$\frac{\partial x_i}{\partial t_i^b} < 0, \qquad \text{sign}\left(\frac{\partial x_i}{\partial g_i}\right) = \text{sign}\left((1-t_i^\ell)\frac{\mathrm{d}w_i}{\mathrm{d}n_i} - (1+t_i^h)\frac{\partial p_i}{\partial n_i}.\right) \tag{54}$$

The first conditions for the three taxing instruments in (54) indicate that the direct negative income effect of taxation always dominates the possibly positive disposable income effect resulting from mobility. The last condition in (54) states that because the public good g_i does not directly enter the equation for prive consumption, its effect only consists of an indirect effect via the housing rent and the wage. In particular, an increase in g_i attracts new residents, increases the rent, alters the wage and thus changes the disposable income. In the case of agglomeration economy and sufficient capitalization of household inflows into the wage, the disposable income increases which increases

[9] See Appendix A for detailed derivations.

the local consumption. On the contrary, if the local wage moderately increases or even decreases ($\psi < 0$), following the entry of new residents in the jurisdiction, consumption decreases.

Similarly, we obtain the cross-effects—that is the effect of one jurisdiction's policy on other jurisdictions—for each policy and $j \neq i$:

$$\text{sign}\left(\frac{\partial x_j}{\partial t_i^b}\right) = \text{sign}\left((1-t_j^\ell)\frac{\partial w_j}{\partial n_j} - (1+t_j^h)\frac{\partial p_j}{\partial n_j}\right), \tag{55}$$

$$\text{sign}\left(\frac{\partial x_j}{\partial g_i}\right) = -\text{sign}\left((1-t_j^\ell)\frac{\partial w_j}{\partial n_j} - (1+t_j^h)\frac{\partial p_j}{\partial n_j}\right). \tag{56}$$

All the above effects are indirect effects resulting from mobility that affect jurisdiction j through changes in its local rent p_j, its local wage w_j, changing its residents' disposable income and consumption. Condition (55) indicates that any increase in jurisdiction i's tax increases the attractiveness of jurisdiction j which increases its rent, alters its wage and thus its disposable income. Depending on the relative capitalization of this mobility into wages and rents, consumption can increase or decrease, as discussed above. The same applies to public good provision as can be seen in condition (56). However, the effect goes in the opposite direction as public good provision allows the jurisdiction changing the policy to attract residents rather than repel them as taxation does.

Special case considered in this subsection assumes inelastic individual housing demand and labor supplies, so that rent and wage incidence only come from household mobility. Thus, it can be shown that in the case of household immobility, i.e. $\mu \to 0$, for all $\tau_i \in \{t_i^n, t_i^h, t_i^x, t_i^\ell, g_i\}$ and $b = n, x, l$, we have for each $i = 1, 2$ and $j = 1, 2$ with $j \neq i$:

$$\frac{\partial n_i}{\partial \tau_i} \to 0 \qquad \frac{\partial x_i}{\partial t_i^b} < 0 \qquad \frac{\partial x_i}{\partial t_i^\ell} < 0 \qquad \frac{\partial x_i}{\partial t_i^x} < 0 \qquad \frac{\partial x_i}{\partial g_i} \to 0 \qquad \frac{\partial x_j}{\partial \tau_i} \to 0,$$

which means that when households' utility is quasi-exclusively derived from their idiosyncratic preference for jurisdictions ($\mu \to 0$), they are immobile ($\partial n_i/\partial \tau_i \to 0$). The effect of taxation on consumption reduces to the direct effect of taxes on disposable income so that $\partial x_i/\partial t_i^b < 0$ and $\partial x_j/\partial t_i^b = 0$. Public good provision entails no direct effect on consumption so that $\partial x_i/\partial g_i \to 0$ and $\partial x_i/\partial g_j \to 0$.

These comparative statics, while not necessary to derive any of the expressions for the MVPF, will provide useful intuition to discuss how researchers must account for open economy concerns when estimating the MVPF of policies at the local level.

5.1.3 MVPFs

Under the assumptions made in section 5.1.1, The local MVPF (34) becomes:

$$LMVPF_{\tau_i} = \frac{\text{DE}_{\tau_i} + (1-t_i^\ell)n_i\dfrac{\partial w_i}{\partial \tau_i} - (1+t_i^h)n_i\dfrac{\partial p_i}{\partial \tau_i}}{\text{ME}_{\tau_i} - n_i\left(t_i^x\dfrac{\partial x_i}{\partial \tau_i} + t_i^h h_i\dfrac{\partial p_i}{\partial \tau_i} + t_i^\ell \ell_i\dfrac{\partial w_i}{\partial \tau_i}\right) + \left(\dfrac{\partial c_i}{\partial n_i}\dfrac{\partial n_i}{\partial \tau_i} - r_i\dfrac{\partial n_i}{\partial \tau_i}\right)}, \tag{57}$$

The direct and mechanical effects in the above expressions are defined as in (36) and (38) but the per capita tax bases (16) become:

$$\text{B}_i^\ell = w_i \qquad \text{B}_i^h = p_i \qquad \text{B}_i^x = x_i \qquad \text{B}_i^n = 1,$$

because of the single-unit individual housing demand and labor supply. With more compact notations, we can write the closed economy $MVPF$, the local MVPF and the social MVPF (assuming unitary social weights) respectively as:

$$CMVPF_{\tau_i} = \frac{\text{DE}_{\tau_i}}{\text{ME}_{\tau_i} + \text{BE}_{\tau_i}^i} \tag{58}$$

$$LMVPF_{\tau_i} = \frac{\text{DE}_{\tau_i} + \text{IE}_{\tau_i}^i}{\text{ME}_{\tau_i} + \text{BE}_{\tau_i}^i + \text{PMC}_{\tau_i}^i} \tag{59}$$

$$SMVPF_{\tau_i} = \frac{(\text{DE}_{\tau_i} + \text{IE}_{\tau_i}^i) + (\text{DE}_{\tau_i}^j + \text{IE}_{\tau_i}^j)}{(\text{ME}_{\tau_i} + \text{BE}_{\tau_i}^i + \text{PMC}_{\tau_i}^i) + (\text{BE}_{\tau_i}^j + \text{PMC}_{\tau_i}^j)} \tag{60}$$

where the direct effect $\text{DE}_{\tau_i}^j$ is as defined in equations (27) and (30) and the mechanical effect ME_{τ_i} is as defined in equation (33), and defining:

$$\text{IE}_{\tau_i}^j = n_j\left((1-t_j^\ell)\frac{\partial w_j}{\partial \tau_i} - (1+t_j^h)\frac{\partial p_j}{\partial \tau_i}\right) \tag{61}$$

$$\text{BE}_{\tau_i}^j = -n_j t_j^x \frac{\partial x_j}{\partial \tau_i} \tag{62}$$

$$\text{PMC}_{\tau_i}^j = -n_j\left(t_j^\ell\frac{\partial w_j}{\partial \tau_i} + t_j^h\frac{\partial p_j}{\partial \tau_i}\right) - \left(r_j - \frac{\partial c_j}{\partial n_i}\right)\frac{\partial n_j}{\partial \tau_i} \tag{63}$$

where $\text{IE}_{\tau_i}^j$ is the disposable effect on the marginal willingness to pay, $\text{BE}_{\tau_i}^j$ is the behavioral effect on the public deficit and $\text{PMC}_{\tau_i}^j$ gathers the price, mobility and congestion cost effects on the public deficit.

5.1.4 The importance of mobility and capitalization in estimating the MVPF

Why does accounting for inter-jurisdictional mobility matter in assessing a public policy when using the MVPF as an indicator? This subsection discusses this issue. If the researcher is able to estimate all the responses in the LMVPF formulas (59), but she assumes that households are immobile so that $\partial n_i/\partial \tau_i = \partial w_i/\partial \tau_i = \partial p_i/\partial \tau_i = 0$ for each policy instrument $\tau_i \in P_i$. In this closed economy case, the relevant MVPF formulas are those of CMVPF defined in (58). In which direction are these "wrong" closed economy estimates of the MVPFs biased compared to the "true" open economy estimates accounting for household mobility? A general answer is that these bias could be in any direction depending on the estimated values of the mobility-driven responses $\partial n_i/\partial \tau_i$, $\partial w_i/\partial \tau_i$ and $\partial p_i/\partial \tau_i$.[10] However, in some particular states of the 2-jurisdiction economy presented in section 5.1.2, the directions of these biases can be unambiguously characterized. Hereafter, we consider two of them.

The first state of the economy which allows to unambiguously compare the MVPFs is characterized by the following assumption:

Assumption 1. *The economy is characterized by significant agglomeration forces:*

(i) Private agglomeration economies are relatively high. That is, for each $i = 1, 2$:

$$(1 - t_i^\ell)\frac{\partial w_i}{\partial n_i} > (1 + t_i^h)\frac{\partial p_i}{\partial n_i} > 0 \tag{64}$$

(ii) Public agglomeration economies are relatively high. That is, for each $i = 1, 2$:

$$r_i > \frac{\partial c_i}{\partial n_i} \tag{65}$$

As $\partial p_i/\partial n_i$ is expected to be always positive from (45), the notable assumption is the left-hand side inequality. It states that population inflows in a jurisdiction exert a sufficiently high upward pressure on the local wage for the disposable income to increase despite the simultaneous housing rent increase. This, of course, requires agglomeration economies ($\psi > 0$), so that wages actually increase as a response to population inflows $\partial w_i/\partial n_i > 0$ (see equation (48)).

Condition (65) states that an additional resident in jurisdiction i increases more the tax revenues than she increases the cost of public good provision. In other words, a new resident allows to reduce

[10] See Table A.1 and Table A.2 in the Appendix for an exposition of the various possible cases.

the local public deficit as public goods are sufficiently weakly rival.

Restating the expression of the MVPFs (58) and (59) with respect to tax instruments, we obtain under Assumption 1, for $b = n, x, l$:

$$LMVPF_{t_i^b} = \frac{\mathrm{DE}_{t_i^b} + \overbrace{\mathrm{IE}_{t_i^b}^i}^{<0}}{\mathrm{ME}_{t_i^b} + \mathrm{BE}_{t_i^b}^i + \underbrace{\mathrm{PMC}_{t_i^b}^i}_{>0}} < \frac{\mathrm{DE}_{t_i^b}}{\mathrm{ME}_{t_i^b} + \mathrm{BE}_{t_i^b}^i} = CMVPF_{t_i^b} \tag{66}$$

where the sign in the numerator results from (50) and (64) and the sign in the denominator comes from (51). Condition (66) indicates that, under Assumption 1, if the researcher assumes that households are immobile, this leads to systematically overestimating the MVPF. More precisely, the numerator in (66) indicates that the researcher would ignore the following marginal welfare cost: taxation discourages some residents to live in the jurisdiction so that wages decrease due to agglomeration economies, which reduces the disposable income. Besides, the denominator in (66) also highlights a missing budgetary cost when using $CMVPF_{t_i^b}$ instead of $LMVPF_{t_i^b}$. Indeed, the reduction in population reduces not only directly the net tax revenues by $|(r_i - \partial c_i/\partial n_i)\partial n_i/\partial t_i^b|$ but also indirectly due to the resulting wage and housing price cuts which reduce the property and labor tax revenues by $n_i|t_i^h \partial h_i/\partial t_i^b + t_i^\ell \partial w_i/\partial t_i^b|$.

Of course, whether these effects are large or small is an empirical question. However, note that for high-income populations, the mobility effects of taxation are non-trivial (Kleven et al., 2020) and often times the mobility elasticities are similar in magnitude to other behavioral responses, such as changes to labor supply (Saez et al., 2012).[11] Moreover, the capitalization effects of taxation are also important (Feldstein and Wrobel 1998,Löffler and Siegloch 2021).

Because the qualitative effect of public good provision (attracting households) on mobility is the opposite of that of taxation (repelling households), the above development allows to immediately state that assessing $CMVPF_{g_i^b}$ (no mobility) instead of $LMVPF_{g_i^b}$ (with mobility) leads to overestimating the MVPF. Restating the expression of the MVPFs (58) and (59) with respect to public

[11] Although households do not generally move in response to commodity tax changes, a more general variant of our model would feature cross-border shopping as a form is mobility. Then, for state and local sales taxes, mobility from cross-border shopping or shifting to online purchases, can exceed the demand changes resulting from tax increases.

good provision, we obtain under Assumption 1:

$$LMVPF_{g_i} = \frac{\text{DE}_{g_i} + \overbrace{\text{IE}^i_{g_i}}^{>0}}{\text{ME}_{g_i} + \text{BE}^i_{g_i} + \underbrace{\text{PMC}^i_{g_i}}_{<0}} > \frac{\text{DE}_{g_i}}{\text{ME}_{g_i} + \text{BE}^i_{g_i}} = CMVPF_{g_i} \tag{67}$$

where the sign in the numerator results from (50) and (64) and the sign in the denominator comes from (52). By attracting new households in the jurisdiction, public good provision entails two mobility-induced benefits: (i) a welfare benefit due to the wage increase resulting from agglomeration economies and (ii) a budgetary benefit because more households and higher wage and rent increase not only all tax revenues, but the property and labor tax revenues in a larger extent.

Again, whether these effects are large or small is an empirical question. For welfare programs, the empirical evidence indicates substantial mobility effects (Agersnap et al., 2020); education programs and other public amenties also attract households to various localities (Epple and Romano, 2003). Finally, capitalization effects are non-trivial (Tiebout, 1956; Oates, 1969), although wage effects resulting from agglomeration may be smaller for lower income households than higher income households (Rosenthal and Strange, 2008), so the validity of the assumption used to derive the bias may depend on the precise nature of the program.

The second state of the economy which allows to unambiguously compare the MVPFs is characterized by the following assumption:

Assumption 2. *The economy is characterized by significant dispersion forces:*

(i) The marginal product of labor is significantly decreasing. That is, for each $i = 1, 2$:

$$t^\ell_i \frac{\partial w_i}{\partial n_i} < -t^h_i \frac{\partial p_i}{\partial n_i} < 0 \tag{68}$$

(ii) Public agglomeration economies are relatively low. That is, for each $i = 1, 2$:

$$r_i < \frac{\partial c_i}{\partial n_i} \tag{69}$$

As a population increase always entail an increase in the housing price, the second inequality in (68) is always satisfied. The first inequality however imposes that not only that the wage decreases as a function of the jurisdiction population, due to sufficiently strong decreasing marginal product of labor ($\psi < 0$), but it also imposes that the wage decreases sufficiently fast compared to the housing rent increases. Condition (68) implies that the price effects of attracting a new resident reduce the jurisdictions' tax revenues, as $t_i^\ell \partial w_i/\partial n_i + t_i^h \partial p_i/\partial n_i < 0$. Condition (69) is the opposite of condition (65). It means that a new resident entails a congestion cost which exceeds the tax revenue that she pays.

Under Assumption 2, condition (66) is reversed:

$$LMVPF_{t_i^b} = \frac{\text{DE}_{t_i^b} + \overbrace{\text{IE}^i_{t_i^b}}^{>0}}{\text{ME}_{t_i^b} + \text{BE}^i_{t_i^b} + \underbrace{\text{PMC}^i_{t_i^b}}_{<0}} > \frac{\text{DE}_{t_i^b}}{\text{ME}_{t_i^b} + \text{BE}^i_{t_i^b}} = CMVPF_{t_i^b} \tag{70}$$

that is, the researcher underestimates the MVPF by ignoring mobility. The closed economy MVPF ignores that residents are ready to pay higher taxes in an open economy, because taxation repels residents out of the jurisdiction and thus reduces the housing rent and increases the local wage: the disposable income increases.

In addition, the $CMVPF$ ignores that household mobility reduce the public deficit for two reasons. First, fewer residents in the jurisdiction means lower costs of public good provision. Second, by leaving the jurisdiction, the residents entail a significant increase in the wage which increases the tax revenues from labor taxation. The cut in property tax revenues due to the reduction in the housing rent is more than compensated by the labor tax revenue increase.

Under Assumption 2, condition (67) is also reversed:

$$LMVPF_{g_i} = \frac{\text{DE}_{g_i} + \overbrace{\text{IE}^i_{g_i}}^{<0}}{\text{ME}_{g_i} + \text{BE}^i_{g_i} + \underbrace{\text{PMC}^i_{g_i}}_{>0}} < \frac{\text{DE}_{g_i}}{\text{ME}_{g_i} + \text{BE}^i_{g_i}} = CMVPF_{g_i} \tag{71}$$

The interpretation of (71) is identical to that of (70). The reasoning is simply reversed as public good provision attracts new residents contrary to taxation which repels residents. The results in this subsection are summarized in the following proposition:

Proposition 1. *Consider a two-jurisdiction economy in which the individual housing demand and labor supply are inelastic. The following results hold:*

(i) If agglomeration forces are relatively high (Assumption 1) then, for tax [public good provision] changes, the closed-economy MVPF overestimates [underestimates] the local MVPF.

(ii) If dispersion forces are relatively high (Assumption 2) then, for tax [public good provision] changes, the closed-economy MVPF underestimates [overestimates] the local MVPF.

5.1.5 Local MVPF versus Social MVPF

Assuming relatively high agglomeration forces as in Assumption 1 or relatively high dispersion forces as in Assumption 2, local and social MVPF can also be unambigously ordered. From the expressions of local MVPF (59) and the social MVPF (60) with respect to any tax instrument t_i^b, under Assumption 1, we have:

$$LMVPF_{t_i^b} = \frac{\text{DE}_{t_i^b} + \text{IE}^i_{t_i^b}}{\text{ME}_{t_i^b} + \text{BE}^i_{t_i^b} + \text{PMC}^i_{t_i^b}} < \frac{\left(\text{DE}_{t_i^b} + \text{IE}^i_{t_i^b}\right) + \overbrace{\text{IE}^j_{t_i^b}}^{>0}}{\left(\text{ME}_{t_i^b} + \text{BE}^i_{t_i^b} + \text{PMC}^i_{t_i^b}\right) + \underbrace{\left(\text{BE}^j_{t_i^b} + \text{PMC}^j_{t_i^b}\right)}_{<0}} = SMVPF_{t_i^b} \quad (72)$$

so that, for each tax instrument, the social MVPF is larger than the local MVPF. The interpretation of this result is as follows.

First, the local MVPF ignores the positive external marginal willingness to pay $EMW^j_{t_i^b} = \text{IE}^j_{t_i^b}$ that the non-residents would be ready to pay for i to increase its tax t_i^b. This willingness to pay is positive because a higher tax in i entails relocation of residents-workers to jurisdiction j in which the wage increases faster than the rent (Assumption 1).

Second, the local MVPF ignores the negative external marginal deficit $EMD^j_{t_i^b} = \text{BE}^j_{t_i^b} + \text{PMC}^j_{t_i^b}$ from which the non-resident benefit as i increases its tax t_i^b. This reduction in the public deficit in j is due to several factors. First, the inflow of new residents in j directly increases the tax revenues net of congestion costs by $(r_j - \partial c_j/\partial n_j)\partial n_j/\partial t_i^b > 0$ (Assumption 1). Second, this increase in population increases the rent and wage in j which increases the tax revenues from labor and property taxation. Finally, as the wage increase dominates the rent increase due to the high level of agglomeration economies (Assumption 1), the disposable income of j's residents increases which also increases the tax revenues from commodity taxation.

Similarly, the social MVPF with respect to any tax instrument g_i can be written as:

$$LMVPF_{g_i} = \frac{\text{DE}_{g_i} + \text{IE}^i_{g_i}}{\text{ME}_{g_i} + \text{BE}^i_{g_i} + \text{PMC}^i_{g_i}} > \frac{(\text{DE}_{g_i} + \text{IE}^i_{g_i}) + \overbrace{(\text{DE}^j_{g_i} + \text{IE}^j_{g_i})}^{<0}}{(\text{ME}_{g_i} + \text{BE}^i_{g_i} + \text{PMC}^i_{g_i}) + \underbrace{(\text{BE}^j_{g_i} + \text{PMC}^j_{g_i})}_{>0}} = SMVPF_{g_i} \tag{73}$$

assuming that in the numerator, the positive spillover effect $\text{DE}^j_{g_i} > 0$ is small compared to the negative disposable income effect $\text{IE}^j_{g_i}$. Equation (73) states that the social MVPF is smaller than the local MVPF. The interpretation is straightforward, as it is the symmetric opposite of that of equation (72): public good provision in i entails outflows of residents from jurisdiction j to jurisdiction i.

Again, Assumption 2, reverses condition (72):

$$LMVPF_{t^b_i} = \frac{\text{DE}_{t^b_i} + \text{IE}^i_{t^b_i}}{\text{ME}_{t^b_i} + \text{BE}^i_{t^b_i} + \text{PMC}^i_{t^b_i}} > \frac{(\text{DE}_{t^b_i} + \text{IE}^i_{t^b_i}) + \overbrace{\text{IE}^j_{t^b_i}}^{<0}}{(\text{ME}_{t^b_i} + \text{BE}^i_{t^b_i} + \text{PMC}^i_{t^b_i}) + \underbrace{(\text{BE}^j_{t^b_i} + \text{PMC}^j_{t^b_i})}_{>0}} = SMVPF_{t^b_i} \tag{74}$$

that is, for tax increases, the local MVPF is larger than the social MVPF because it ignores negative welfare and budget spillovers exerted on other jurisdictions.

First, by increasing its tax, jurisdiction i increases the population in the other jurisdictions and thus reduces their individual disposable income. Thus, non-residents would be ready to pay for i not to increase its tax.

Second, the inflow of residents in the other jurisdictions increase their public deficits through several channels. More residents means higher costs of public good provision. Moreover, by reducing the wage, these new residents entail are direct decrease in the labor tax and an indirect cut in the commodity tax as the consumption decreases.

Similarly, Assumption 2, reverses condition (73):

$$LMVPF_{g_i} = \frac{\text{DE}_{g_i} + \text{IE}^i_{g_i}}{\text{ME}_{g_i} + \text{BE}^i_{g_i} + \text{PMC}^i_{g_i}} < \frac{(\text{DE}_{g_i} + \text{IE}^i_{g_i}) + \overbrace{(\text{DE}^j_{g_i} + \text{IE}^j_{g_i})}^{>0}}{(\text{ME}_{g_i} + \text{BE}^i_{g_i} + \text{PMC}^i_{g_i}) + \underbrace{(\text{BE}^j_{g_i} + \text{PMC}^j_{g_i})}_{<0}} = SMVPF_{g_i} \tag{75}$$

whose interpretation follows the same lines as that of condition (74). The results in this subsection are summarized in the following proposition:

Proposition 2. *Consider a two-jurisdiction economy in which the individual housing demand and labor supply are inelastic. The following results hold:*

(i) If agglomeration forces are relatively high (Assumption 1) then, for tax [public good provision] changes, the social MVPF is larger [smaller] than the local MVPF.

(ii) If dispersion forces are relatively high (Assumption 2) then, for tax [public good provision] changes, the social MVPF smaller [larger] than the local MVPF.

5.2 Quantitative model

In this subsection we consider specific functional forms that allow us to report numerical simulation results of how much the social and local MVPF diverge from each other. The purpose of these simulation is to describe the interplay between local and social MVPFs, documenting that quantitative evaluations of these MVPFs can significantly differ from each other as well as a closed-economy version of the MVPFs. Section 5.2.1 describes the functional specifications chosen. Section 5.2.2 characterizes the spatial general equilibrium. Section 5.2.3 reports the results of the numerical simulations.

5.2.1 Specification

Consider the economy described in section 2 in the specific case where it includes only $M = 2$ identical jurisdictions $i = 1, 2$. The two jurisdictions are initially symmetric but as we are interested in a policy change in only one of them, say jurisdiction 1, they will marginally differ ex-post. Therefore, this necessitates we solve the model heterogeneous jurisdictions.

The utility function of the representative resident of jurisdiction i (4) takes the familiar Cobb–Douglas form:

$$U(x_i, h_i, \ell_i, g_i, g_{-i}) + e_i = x_i^{\alpha} h_i^{\beta} (\bar{\ell} - \ell_i)^{1-\alpha-\beta} G_i + e_i \qquad \text{with } G_i = g_i^{\gamma_1} g_{-i}^{\gamma_2} \tag{76}$$

where the preference parameters α, β, γ_1 and γ_2 are in $(0, 1)$, and $\gamma_2 < \gamma_1$. Parameter γ_2 reflects the extent to which a resident of jurisdiction i benefit from the public provided in the other jurisdiction due to spillovers and is assumed less than the direct-benefit of own-jurisdiction spending. Parameter

$\bar{\ell}$ is the amount of time available to an individual. The individual divides this time endowment into ℓ_i units of labor time and $\bar{\ell} - \ell_i$ units of leisure time.

The production function of the representative firm in jurisdiction i (8) is:

$$f(l_i, L_i, z_i, z_{-i}) = l_i^a L_i^b Z_i \qquad \text{with } Z_i = z_i^{d_1} z_{-i}^{d_2} \tag{77}$$

where the technology parameters a, b, d_1 and d_2 are in $(0, 1)$. Parameter b represents the degree of agglomeration economies: the elasticity of a firm's production with respect to the amount of labor employed by all the firms in the jurisdiction. Parameter d_2 reflects the degree of business public service spillovers.

The public cost function of jurisdiction i (13) is:

$$c(g_i, z_i, n_i, n_{-i}, L_i, L_{-i}) = g_i \left(n_i + \kappa_g n_{-i}\right)^{\phi_g} + z_i \left(L_i + \kappa_z L_{-i}\right)^{\phi_z}$$

where $0 \leq \kappa_k \leq 1$ and $0 \leq \phi_k \leq 1$. For example, if $\kappa_g = \phi_g = 1$, g_i is a publicly provided private good and if $\phi_g = 0$, g_i is a pure local public good.

The housing production cost function in (11) is:

$$c_i^h(H_i) = \frac{\epsilon\delta}{1+\delta} \left(\frac{H_i}{\epsilon}\right)^{\frac{1+\delta}{\delta}} \tag{78}$$

where $\delta > 0$ and $\epsilon > 0$.

5.2.2 Spatial general equilibrium

We can now characterize the spatial general equilibrium of the model and provide intuition into the interplay of the model key variables, given the specification described in section 5.2.1.

Consumers The representative consumer of jurisdiction i chooses her private consumption x_i, housing consumption h_i and labor supply ℓ_i so as to maximizes her utility (76) subject to her budget constraint (5):

$$(1 + t_i^h)p_i h_i + (1 + t_i^x)x_i = y + (1 - t_i^\ell)w_i \ell_i - t_i^n$$

which shows that we ignore the federal government in this application. Moreover, we assume that the non-labor income y is fully exogenous, all the firms being possessed by absentee owners. The resulting Marshallian demands and labor supply of the consumer are:

$$\begin{aligned} x_i(p_i, w_i, \mathbf{t}_i) &= \frac{\alpha}{1+t_i^x}(y + (1-t_i^\ell)w_i\bar{\ell}) \\ h_i(p_i, w_i, \mathbf{t}_i) &= \frac{\beta}{(1+t_i^h)p_i}(y + (1-t_i^\ell)w_i\bar{\ell}) \\ \ell_i(p_i, w_i, \mathbf{t}_i) &= \bar{\ell} - \frac{1-\alpha-\beta}{(1-t_i^\ell)w_i}(y + (1-t_i^\ell)w_i\bar{\ell}) \end{aligned} \tag{79}$$

To make transparent the direct effect of taxes on individual demands and labor supply, let us state the standard responses to price changes implied by expressions (79). Individual demands are decreasing with respect to own prices. That is, an increase in the gross price of the numéraire good [housing] reduces its consumption and an increase in the wage reduces leisure consumption and thus increases the individual labor supply. Expressions (79) also entail the standard Cobb-Douglas absence of cross price effects. That is, an increase in the gross price of the numéraire good [housing] affects neither the housing [numéraire good] consumption nor the labor supply. Moreover, expressions (79) imply that income effects are unambiguously positive: that is, an increase in the net wage increases the consumptions of numéraire good and housing.

Inserting the Marshallian expressions (79) into the utility function (76), we obtain the indirect utility function:

$$V_i(p_i, w_i, \mathbf{t}_i, \mathbf{g}) + e_i = \frac{\Gamma\left[y + (1-t_i^\ell)w_i\bar{\ell}\right]G}{(1+t_i^x)^\alpha\left[(1+t_i^h)p_i\right]^\beta\left[(1-t_i^\ell)w_i\right]^{1-\alpha-\beta}} + e_i \tag{80}$$

where $\Gamma = \alpha^\alpha\beta^\beta(1-\alpha-\beta)^{1-\alpha-\beta}$. To gain intuition about how households' location are expected to respond to policy changes, it is useful to state the sign of the direct effect of changes in the level of policy instruments on the indirect utility. From (80), it is straightforward to show that the taxes and the public goods have expected direct effects on the utility function. An increase in either tax reduces the related consumption and thus the utility function. Increasing the net labor income increases utility due to a positive income effect on the consumptions of the private good, housing and leisure. An increase in public good provision increases the utility of the residents and that of the non-residents in a lesser extent.

Finally, differentiating the indirect utility (80) with respect to the non-labor income, we obtain the expression of the marginal utility of income (24):

$$\lambda_i \equiv \frac{\partial V_i}{\partial y} = \frac{\Gamma G}{(1+t_i^x)^\alpha \left[(1+t_i^h)p_i\right]^\beta \left[(1-t_i^\ell)w_i\right]^{1-\alpha-\beta}} > 0$$

which is unambiguously positive as increasing non-labor income only entail a positive income effect on all consumptions.

Production Each of the m_i firms in jurisdiction i choses its labor demand so ast to maximize its profit (2.2), $f(l_i, L_i, z_i, z_{-i}) - w_i l_i$ where $f(\cdot)$ is the production function defined in (77). The individual firm's first-order conditions allow to derive the aggregate labor demand in jurisdiction i:

$$L_i(w_i, z_i, z_{-i}) = \left(\frac{w_i}{a m_i^{1-a} Z_i}\right)^{\frac{1}{a+b-1}} \tag{81}$$

which is the aggregate labor demand function of jurisdiction i characterized generally in (9). The demand function (81) characterizes the maximum amount of labor employed by the firms in jurisdiction i given the wage w_i. Alternatively, (81) can be written as an inverse demand function:

$$w_i(L_i, z_i, z_{-i}) = a L_i^{a+b-1} m_i^{1-a} Z_i \tag{82}$$

which is equivalent to but easier to interpret than the demand function (81) in the presence of agglomeration economies. The inverse demand function (82) is the maximum wage that the firms in i are ready to pay if L_i units of labor are available in i. Differentiating (82) with respect w_i, z_i and z_{-i} and recalling that $0 < a < 1$, we obtain:

$$\frac{\partial w_i}{\partial m_i} > 0, \qquad\qquad \frac{\partial w_i}{\partial z_i} > \frac{\partial w_i}{\partial z_{-i}} > 0, \tag{83}$$

in which the first condition indicates that the larger the number of firms, the fiercer the competition for workers and thus the higher the wage the firms are ready to pay. The right-hand side condition in (83) indicates that a larger provision of business public service increases workers' productivity and thus the wage that the firms are ready to pay. As expected, local business public service have a stronger effect on the local wage than business public service provided outside, because $d_1 > d_2$ is assumed in (77).

$$\frac{\partial w_i}{\partial L_i} \gtreqless 0 \iff b \gtreqless 1-a \tag{84}$$

If the degree of agglomeration economies b is relatively low, i.e. $b < 1 - a$ ($b = 0$, for example), the wage decreases as the amount of workers in the jurisdiction increases: due to decreasing marginal products, the last worker is less productive if the workforce is already important. However, if agglomeration economies are large enough, i.e. $b > 1 - a$, the wage increases as a function of the labor force: due to agglomeration economies, the last worker is more productive if it can interact with many workers.

The housing sector chooses the stock of housing supplied H_i so as to maximize the profit$p_i H_i - c^h(H_i)$ where the cost function $c^h(H_i)$ is as defined in (78), so that the housing supply function is:

$$H_i(p_i) = \epsilon p_i^{\delta} \tag{85}$$

which is, as expected, increasing with respect to the housing rent p_i, because $\epsilon, \delta > 0$.

General equilibrium Inserting the individual housing demand (79) and the housing supply (85) into the housing market clearing condition (20), $n_i h_i(p_i, w_i, \mathbf{t}_i) = H_i(p_i)$, we obtain:

$$n_i \beta \frac{y + (1 - t_i^{\ell}) w_i \bar{\ell}}{(1 + t_i^h) p_i} = \epsilon p_i^{\delta} \tag{86}$$

Inserting the individual labor supply (79) and the aggregate labor demand (81) into the labor market clearing condition (21), $n_i \ell_i(p_i, w_i, \mathbf{t}_i) = L_i(w_i, z_i, z_{-i})$, we obtain:

$$n_i \left(\bar{\ell} - \frac{1 - \alpha - \beta}{(1 - t_i^{\ell}) w_i} (y + (1 - t_i^{\ell}) w_i \bar{\ell}) \right) = \left(\frac{w_i}{a Z_i m_i^{1-a}} \right)^{\frac{1}{a+b-1}} \tag{87}$$

The number of households choosing to live in jurisdiction i (18) is:

$$n_i = \frac{N}{1 + \exp\left[\mu V(p_{-i}, w_{-i}, \mathbf{t}_{-i}, \mathbf{g}) - \mu V(p_i, w_i, \mathbf{t}_i, \mathbf{g}) \right]} \tag{88}$$

where the indirect utility function $V(\cdot)$ is as defined in (80). For $i = 1, 2$, the 6 conditions (20), (21) and (88), implicitly define the housing rents, p_1 and p_2, the wages, w_1 and w_2 and the populations, n_1 and n_2. Although this 6-equation system cannot be algebraically solved for p_i, w_i and n_i, $i = 1, 2$, it can be solved numerically.

5.2.3 Simulation results

We can now simulate numerically the model to address the main purpose of section 4.4: evaluate the different MVPFs (LMVPF, EMVPF and SMVPF) to provide intuition into why they differ from each other and compare to a MVPF that ignores open economy forces. We proceed as follows. The first paragraph reports the model calibration and the resulting symmetric 2-jurisdiction equilibrium. The second paragraph reports the responses of the key endogenous variables present in the MVPF formulas to policy changes. The last paragraph reports the numerical evaluation of the different $MVPFs$.

Equilibrium Table 3 reports the calibration of the model functions introduced in section 5.2.1.[12] As jurisdictions are ex-ante symmetric, it is natural to focus on the endogenous symmetric equilibrium among jurisdictions. The equilibrium levels of the key endogenous variables of the model are reported Table 2.

Table 2. Endogenous symmetric equilibrium.

Variable	Definition	Value
n_i	Population	5
x_i	Individual consumption of numéraire good	1.01
h_i	Individual housing consumption	0.43
ℓ_i	Individual labor supply	0.68
w_i	Wage	1.19
p_i	Housing rent	1.39
λ_i	Individual marginal utility of income	0.13

[12] This calibration is chosen to be as intuitive as possible but it does rely on some empirical data and literature estimates. We are currently looking for more relevant parameter values in the literature.

Table 3. Calibration of the exogenous parameters and variables.

Parameter/ Variable	Definition	Value
A. Policy instruments		
t_i^x	Commodity tax rate	0.08
t_i^h	Housing tax rate	0.2
t_i^ℓ	Labor tax rate	0.06
t_i^n	Head tax	−0.05
g_i	Public good provision	0.15
z_i	Public input provision	1
B. Exogenous variables		
$\underline{y}$	Individual non-labor income	1
$\bar{\ell}$	Individual available time	1
N	Total population	10
m_i	Numer of firms	4
C. Parameters		
C.1. Utility function		
α	Private consumption expenditure share	0.5
β	Housing expenditure share	0.33
$\gamma 1$	Utility elasticity of local public good	0.25
$\gamma 2$	Utility elasticity of public good spillover	0.17
C.2. Numéraire production function		
a	Output elasticity of a firm's labor input	0.8
b	Output elasticity of agglomeration economies	0.3
d_1	Output eslaticity of local public inputs	0.2
d_2	Output elasticity of public input spillover	0.17
C.3. Public cost function		
κ_g	Degree of public good congestion due to spillover	0.5
κ_z	Degree of public input congestion due to spillover	0.5
ϕ_g	Degree of rivalness of public goods	1
ϕ_z	Degree of rivalness of public inputs	1
C.4. Housing production function		
δ	Housing supply elasticity	0.25
ϵ	Scale parameter of the housing supply	2
C.5. Other		
μ	Degree of mobility	2
ψ_i	Social weight	1

NOTE— The expenditure shares α and β are relative to total potential income that the individuals would earn if they used all their available time to work, as can be seen in the Marshallian demand functions (79).

Policy responses The marginal value of public funds is exclusively composed of marginal responses of the endogenous variables of the model to policy changes. Hence, it is critical to understand how the key endogenous variables of the model respond to policy changes. Table 4 reports the magnitude of these responses as a given jurisdiction, $i = 1$, marginally increases one of its instruments: its head tax t_1^n, its commodity tax t_1^x, its property tax t_1^h, its public good provision g_1 or its business public service provision z_1.

Table 4. Responses to a marginal increase in jurisdiction 1's policy instruments.

	Policy instrument τ_1					
	(1)	(2)	(3)	(4)	(5)	(6)
	t_1^n	t_1^x	t_1^ℓ	t_1^h	g_1	z_1
A. Rents and wages						
$\partial p_1/\partial\tau_1$	−0.596	−0.136	−0.692	−0.942	0.163	0.13
$\partial p_2/\partial\tau_1$	0.097	0.136	0.068	0.016	−0.163	−0.013
$\partial w_1/\partial\tau_1$	0.017	−0.014	−0.037	−0.002	0.017	0.245
$\partial w_2/\partial\tau_1$	0.01	0.014	0.007	0.002	−0.017	−0.001
B. Consumption and labor supply						
$\partial x_1/\partial\tau_1$	−0.456	−0.937	−0.568	−0.001	0.007	0.107
$\partial x_2/\partial\tau_1$	0.004	0.006	0.003	0.001	−0.007	−0.001
$\partial h_1/\partial\tau_1$	−0.01	0.04	−0.029	−0.068	−0.048	0.005
$\partial h_2/\partial\tau_1$	−0.029	−0.04	−0.02	−0.005	0.048	0.004
$\partial \ell_1/\partial\tau_1$	0.151	−0.002	−0.171	0.	0.002	0.032
$\partial \ell_2/\partial\tau_1$	0.001	0.002	0.001	0.	−0.002	0.
C. Population and workforce						
$\partial n_1/\partial\tau_1$	−0.417	−0.579	−0.289	−0.07	0.695	0.054
$\partial n_2/\partial\tau_1$	0.417	0.579	0.289	0.07	−0.695	−0.054
$\partial L_1/\partial\tau_1$	0.472	−0.402	−1.05	−0.048	0.482	0.197
$\partial L_2/\partial\tau_1$	0.289	0.402	0.2	0.048	−0.482	−0.038

We discuss several results. First, the variations of the populations n_i in panel C of Table 4 intuitively indicates that any tax increase in jurisdiction 1 pushes residents toward jurisdiction 2, but an increase in the public good provision attracts residents in jurisdictions 1.

Second, the variations of the amounts of labor L_i in panel C indicate that the amount of labor changes are in the same direction as the population, except that the head tax reduces the number of residents in 1 but as each one works much more, the workforce increases.

Third, the variations of the housing rents p_i in panel A indicates that, as expected, the changes in the population due to mobility are systematically reflected in housing rent capitalization: a population increase [decrease] results in a housing rent increase [decrease].

Fourth, similarly, the variations of the wages w_i in panel A indicates that wages vary in the same direction as employment L_i, due to agglomeration economies. This is a direct application of result (84), as we indeed have assumed $b > 1 - a$ according to Table 3.

Fifth, the consumption and labor supply responses in panel B are more difficult to interpret as they reflects not only tax changes but also changes in the local wage and housing rent. However, the standard Marshallian responses with respect to price changes for Cobb Douglas utility functions dominate in jurisdiction 1. Namely, the commodity tax decreases the consumption of numéraire ($\partial x_1/\partial t_1^x < 0$), the housing tax decreases the housing consumption ($\partial h_1/\partial t_1^h < 0$) and the labor tax decreases labor supply and all consumption variables ($\partial \ell_1/\partial t_1^\ell < 0$, $\partial x_1/\partial t_1^\ell < 0$ and $\partial h_1/\partial t_1^\ell < 0$).

Table 5. Marginal values of public funds.

	Policy instrument τ_1					
	(1)	(2)	(3)	(4)	(5)	(6)
	t_1^n	t_1^x	t_1^h	t_1^ℓ	g_1	z_1
	I. Closed Economy					
A. Local MVPF						
LMVPF^C	0.931	1.22	1.048	2.352	0.231	0.
Numerator	−5.	−2.78	−1.737	−3.582	1.737	0.
Denominator	−5.369	−2.278	−1.657	−1.523	7.511	4.349
B. Social MVPF						
SMVPF^C	0.944	1.25	1.053	2.417	0.386	0.
Numerator	−5.	−2.78	−1.737	−3.582	2.895	0.
Denominator	−5.299	−2.224	−1.65	−1.482	7.5	4.345
	II. Mobility and Capitalization					
A. Local MVPF						
LMVPF	0.926	1.155	0.242	0.581	0.225	0.045
Numerator	−3.275	−2.516	−0.314	−1.888	1.682	0.189
Denominator	−3.535	−2.179	−1.297	−3.249	7.491	4.163
B. External MVPF						
EMVPF	−0.509	5.841	5.841	0.164	128.889	0.164
Numerator	−0.344	−0.264	−0.033	−0.198	1.213	0.02
Denominator	0.675	−0.045	−0.006	−1.208	0.009	0.121
C. Social MVPF						
SMVPF	1.265	1.25	0.267	0.468	0.386	0.049
Numerator	−3.618	−2.78	−0.347	−2.087	2.895	0.209
Denominator	−2.86	−2.224	−1.303	−4.457	7.5	4.284

First, comparing the local and social MVPF formulas in (41) and (42) to those in (40) resulting from Hendren (2016), we observe that they only differ because of the mobility effects, M_{ij}, the capitalization effects, $W_{ij} + R_{ij} + \Pi_{ij}$ and P_{ij}, and the business public service congestion effects C_{ij}. That is, if empirical reduced-form estimates of these three effects are not significantly different from zero, the empirical researcher looses nothing to the simpler closed economy formulas (40).

However, as Table 6 indicates, our quantitative model suggests that observable estimates are likely to be non-zero in most cases. The MVPFs relative to the housing tax and the labor tax in columns 3 and 4 of Table 5 confirm that evaluations of the local MVPFs can be significantly different whether one ignores mobility and capitalization effects or not.

Moreover, Table 5 indicates that accounting for mobility and capitalization effects introduces important level differences between the local MVPF and the social MVPF, contrary to what can be observed considering the formulas derived in Hendren (2016).

Table 6. Components of the marginal values of public funds.

	Policy instrument τ_1					
	(1)	(2)	(3)	(4)	(5)	(6)
	t_1^n	t_1^x	t_1^h	t_1^ℓ	g_1	z_1
A. Local MVPF						
A.1. Numerator						
DE_{11}	−5.	−5.025	−3.015	−4.038	18.092	0.
W_{11}	0.053	−0.045	−0.005	−0.118	0.054	0.781
R_{11}	1.554	0.353	2.455	1.804	−0.424	−0.339
A.2. Denominator						
ME_{11}	−5.	−5.025	−3.015	−4.038	7.5	5.079
B_{11}	0.143	0.32	0.094	0.329	0.062	−0.062
P_{11}	0.256	0.062	0.409	0.308	−0.074	−0.106
M_{11}	0.052	0.072	0.009	0.036	−0.087	−0.007
C_{11}	0.617	−0.201	−0.024	−0.95	0.241	0.179
B. External MVPF						
B.1. Numerator						
DE_{12}	0.	0.	0.	0.	12.061	0.
W_{12}	0.032	0.045	0.005	0.022	−0.054	−0.004
R_{12}	−0.254	−0.353	−0.042	−0.176	0.424	0.033
B.2. Denominator						
B_{12}	0.037	0.052	0.006	0.026	−0.062	−0.005
P_{12}	−0.044	−0.062	−0.007	−0.031	0.074	0.006
M_{12}	−0.052	−0.072	−0.009	−0.036	0.087	0.007
C_{12}	0.525	0.201	0.024	−0.325	−0.241	0.061

NOTE— The terms in the first column are as defined in Table 1.

Second, equation (41) highlights that previous literature has overlooked a possibly informative policy indicator: the external MVPF. As Table 5 shows, the EMVPF can be particularly high compared to the local MVPF. However, we can also observe that the social MVPF is much closer to the local MVPF than to the external MVPF. This is due to the fact, already mentioned, that cross-jurisdiction effects are relatively low compared to local effects.

6 From Theory to Practice

The inclusion of mobility effects in the calculation of the MVPF necessitates care when selecting what causal estimates to utilize for the MVPF. In this section, we provide some guidance.

6.1 Can Behavioral and Mobility Effects Be Estimated Jointly?

Initially, consider a case with a single taxing instrument on labor or alternatively assume that any cross-base effects are negligible. Does the researcher need to estimate labor supply and mobility effects separately or jointly? In the absence of congestible public goods, both effects can be used to calculate the fiscal externality. To see this, note that the behavioral effect, the price effect, and the mobility effect can be combined into $-n_i t_i^\ell w_i \frac{\partial \ell_i}{\partial t_i^\ell} - n_i t_i^\ell \ell_i \frac{\partial w_i}{\partial t_i^\ell} - t_i^\ell w_i \ell_i \frac{\partial n_i}{\partial t_i^\ell}$. Applying the product rule, one can easily see that this is the derivative of labor tax revenues or alternatively of the labor tax base: $\frac{\partial (t_i^\ell n_i w_i \ell_i)}{\partial t_i^\ell} = t_i^\ell \frac{\partial (n_i w_i \ell_i)}{\partial t_i^\ell}$. Thus, estimating the denominator of the MVPF could be done with aggregate data or alternatively, researchers could use disaggregated data to estimate $\frac{\partial (w_i \ell_i)}{\partial t_i^\ell}$ and $\frac{\partial n_i}{\partial t_i^\ell}$ separately. However, in the presence of congestion effects on the public services, the researcher will need to estimate the effect of the tax on the number of beneficiaries to the program. This mobility effect will then need to be scaled by the effect of the number of individuals on budgetary costs.

However, neither using aggregate data to estimate the total effect or using disaggregated data to separately estimate the the effect on mobility and $w_i \ell_i$ will allow the researcher to calculate the numerator of the MVPF. Here, researchers must estimate the effect of the policy on prices directly.

The same logic above can easily be extended to multiple tax instruments. The fiscal externality on other tax bases can be estimated by calculating the effect using either the disaggregated components or the combined total effect.

6.2 Individual Data vs. Aggregate Data

Again, consider the behavioral responses to a labor income tax, although the points we make below apply more generally. A common way of capturing the behavioral responses to labor income taxes is by estimation of the elasticity of taxable income (Saez et al., 2012). Speaking generally, there are then three ways a research could estimate this elasticity. First, the researcher could utilize individual data and estimate taxable income responses holding constant the wage rate faced by the individual. Second, also utilizing individual data, the researcher might not control for wages in the specification. Finally, the researcher could utilize aggregate data on total hours worked in the economy to estimate the response.

Critically, calculation of the MVPF relies on uncompensated elasticites. But, in a federal system, how these elasticities are estimated determines whether the elasticity includes mobility effects or not. If using state-level administrative data on taxfilers, it is likely the ETI would be estimated using individuals who appear in the data before and after the tax reform. Including individuals who leave the state's data would require knowledge about whether it was a result of a move, death of a taxpayer, or simply a result of losing contact with tax administration. In this case, mobility responses would not be included in the ETI. Now one might expect this problem could be overcome by accessing federal tax return data. And while this is true, studies of the ETI traditionally drop movers to avoid complex changes resulting from different state tax systems. Again, the ETI would exclude mobility responses, necessitating their separate estimation.

This stands in contrast to aggregate data. When using aggregate data on total taxable income (or labor supply), the researcher is essentially studying the number of taxpayers times average taxable income. In this way, aggregate data will capture both real labor supply responses and declines in the number of workers (both extensive and intensive margin effects).

Critically, in the presence of congestion effects, our MVPF formula makes it clear that the researcher will obtain need to estimate the labor supply and mobility responses *separately*. Critically, changes in the number of individuals also influences the congestion costs of providing the local public services, while labor supply or price response do not.

6.3 Do Mobility Effects on Prices Need to Be Estimated Separately?

Calculation of the MVPF also requires separate information on the pricing effect because the willingness to pay depends only on the price and not the quantity effect of the policy. Again, using the example of labor supply, wages may change for two reasons. First, behavioral effects on labor supply may changes to labor supply via standard general equilibrium pricing effects. Second, mobility of workers across jurisdictions may also change wages. Critically, our MVPF makes it clear that price changes do not need to be decomposed into whether they are a result of mobility or not. In other words, the reason why prices are changing is irrelevant to determine the fiscal externality or the change in willingness to pay. As a result standard reduced form estimates of pricing effects suffice.

6.4 Estimating Interjurisdictional Fiscal Externalities

The local public finance literature (Buettner 2003; Agrawal et al. 2021) has estimated cross-jurisdiction effects, but more work is needed in this area. As is clear in (37) and (39), calculating the social MVPF requires calculating the interjurisdictional fiscal externalities. At first glance, estimating all the necessary components may seem complicated. Researchers need to know the effect of jurisdiction i's policy on every other jurisdiction's budget individually. One might initially believe that this implies the researcher needs to estimate the effect of the policy on $M-1$ other jurisdiction in the country separately. But as indicated in (39), only the total interjurisdictional externality is needed. Further, in this section, we argue that one can make reasonable assumptions that allow researchers to estimate the aggregate effect on other jurisdictions. Of course, as noted in Finkelstein and Hendren (2020), estimating the effect of a policy that spills over onto non-beneficiaries is challenging, and so too is the case for cross-jurisdiction effects.

First, in cases where mobility is localized to nearby jurisdictions, the researcher can assume that fiscal externalities on far away jurisdictions are negligible. This might be the case for elementary schooling if individuals choose from school districts within a common metropolitan area. Notice that a tax or expenditure base for jurisdiction j can be written as $b_j = b(\tau_j, \tau_{-\mathbf{j}}, X_j)$, where τ_j is the policy in the jurisdiction, $\tau_{-\mathbf{j}}$ is the full vector of policies in all other jurisdictions other than j, and X_j are jurisdiction characteristics. If the base is locally mobile, then the researcher can simplify by noting the base only will depend on nearby policies. In this case, following Buettner (2003), the researcher might estimate an equation of the form

$$b_{jt} = \alpha\tau_{jt} + \sum_{k\neq j} \beta_k \tau_{kt} + X_{jt}\gamma + \epsilon_{jt} \tag{89}$$

where b_{it} is the tax base in jurisdiction j and year t and X_{it} are controls including appropriator fixed effects. Alternatively, the researcher might use revenue data rather than base data. The researcher must take care to find a causal identification strategy, perhaps instruments to resolve endogeneity concerns. Then consider a policy such as education spending, τ_{jt}. By controlling for own-jurisdiction spending, the researcher accounts for the fact that high-education spending at home will expand the own jurisdiction's tax base and revenues ($\alpha > 0$). Then, keeping in mind that the researcher has assumed mobility is only among nearby jurisdictions within the metro area, the summation $\sum_{k\neq j} \beta_k \tau_k$ may be restricted to only the proximate set of towns. Such a sufficient number of exogenous sources of variation and a large number of observations, which may not exist in practice. Then, assumptions can be made such that $\sum_{k\neq j} \beta_k \tau_k = \beta\overline{\tau}_{-jt}$ where the right hand side denotes the (weighted) average of education spending in the metropolitan area. Theory might provide insight on the weights: if all jurisdictions are equally attractive, then a raw average suffices. If moving costs increase with distance, then inverse distance weights might be appropriate. In general form, $\overline{\tau}_{-jt} = \sum_{j\neq i} w_{ji}\tau_j$ where w_{ji} are the weights given to each jurisdiction. Then, an increase in spending of nearby jurisdictions ($i \neq j$) will shrink the tax base of jurisdiction j (i.e., $\beta < 0$) via an outflow of mobility. If the outcome variable is revenue, then β pins down the interjurisdictional fiscal externality. However, note that because $\overline{\tau}_{-jt}$ is an average, it tells us the effect of a one unit increase in spending in all nearby jurisdictions. If one wishes to study the effect of a one unit increase in a single jurisdiction, one must appropriately rescale it by the weights used to construct the average. Finally, note that if the researcher uses tax base data or prices, the estimates need to be multiplied by the tax rate of the jurisdiction to determine the fiscal externality.

Second, in cases where mobility may be global, one may wish to identify these effects by exploiting how state-level revenue data in all other jurisdictions changes following a policy change in one state. Note that $\sum_{\substack{j=1 \\ j \neq i}}^{M} EMD^{j}_{\tau_i}$ can be rewritten as $(M-1)\overline{EMD}_{\tau_i}$ where $\overline{EMD}_{\tau_i}$ is the mean external effect and M is the total number of jurisdictions in the economy. Then, the researcher needs to simply take care to to estimate the average fiscal externality and multiply by the number of other states to obtain the total fiscal externality. Of course, such a strategy may require accounting for policy changes happening across multiple states at various points in time. If the policy changes are small and the number of states large, even identifying the effect on the average state may be difficult.

If the external effects on any one other state are small, a third approach taken in Agrawal et al. (2021), exploits the estimation of own-jurisdiction effects to reverse engineer the fiscal externality. Here estimation is best explained using their specific example: following fiscal decentralization of wealth taxes in Spain, the region of Madrid lowered its wealth tax rate to zero; all other jurisdictions maintained high tax rates. The authors use this salient deviation to causally estimate the migration to Madrid. Then, assuming that Spain is a closed economy without international flows being altered by the tax, any increase in Madrid's population caused by the wealth tax decrease must be a loss elsewhere. If all other regions levied identical tax rates, then obtaining the fiscal externality is trivial. Given other regional tax rates differ, assumptions must be made. The authors apportion their causal effect using the pair-specific regional migration changes (post- minus pre-reform) and then reassign movers randomly back to their home region, which allows them to calculate the precise loss of in the tax base of each other region. The authors then use microdata on taxes actually paid, plus a tax simulator to calculate the counterfactual lost wealth, labor income, and capital income taxes resulting from this mobility. Summing across region then gives the total interjurisdictional fiscal externality due to mobility necessary for the MVPF. Of course, this ignores price effects, which the authors argue are negligible because the "mobility" is either fake or high-wealth individuals already own properties. Under this third approach, the researcher uses the migration into the jurisdiction making the policy change, and reasonable assumptions on where it originates from, to infer the fiscal externality on other states.

6.5 How to Estimate Congestion Costs?

Estimates of the effect of population size on the costs of public service production often follow a structural approach (Borcherding and Deacon, 1972; Bergstrom and Goodman, 1973; Brueckner, 1981; Oates, 1988; Duncombe and Yinger, 1993). In its most basic form, these studies estimate a multiplicative demand function that contains the population of the jurisdiction as one of its arguments. From the estimated coefficient on the population variable and the price elasticity, the researcher can then estimate a congestion parameter that measures the effect of the increase in population on the public service. As a simple example, the relationship between public service consumption and population might take the form $g_i = s_i n_i^{-\kappa}$ where s is the number of units provided by the locality and g is a final output of interest to residents or the amount of the good consumed by an individual (what enters into the utility function). Then, $\kappa = 0$ for a public good and $\kappa = 1$ for a private good. Traditionally, studies, assume that this congestion parameter is the same for all communities, but not across goods. Obviously, more complex functions and structural approaches might lead to less bias from a misspecification of the form. Of course, much of the older literature might not be considered as causal, but this approach could be extended using modern tools of demand function estimation from the industrial organization literature. Such cost functions have often been omitted from recent structural models. Our paper suggests that including such congestion may be a critical way to model public services if seeking to utilize the MVPF.

6.6 How to Estimate Spillover Benefits?

While the existence of spillover benefits or costs has long been acknowledged in the public finance literature, quantifying these benefits and costs has proven to be a challenge with few examples found in the literature. What might be an approach to obtain estimating the extent of these spillovers? We suggest the possibility of employing hedonic estimation. A standard use of hedonics is to relate property values in a jurisdiction to the taxes and public services in that jurisdiction by estimating equation of the form:

$$V_{hj} = \alpha + \beta g_j + \gamma t_j + \delta X_{hj} + \varepsilon_{hj} \tag{90a}$$

where V_{hj} is the value of house h in jurisdiction j or more frequently the log of property value; g_j is the level of public service, t_j is the property tax rate; and X_{hj} are characteristics of the house. Then, if the jurisdiction has a small share of the federation's population its policies will have a negligible effect on property values in other jurisdictions and the coefficient on g_j, β, will provide an estimate of the marginal willingness to pay for g_j.

We can apply the same procedure to estimate the "spillover" benefits from public goods provided in neighboring jurisdictions. Then, we can amend (90a) to include public goods in other jurisdictions giving

$$V_{hj} = \alpha + \beta_j g_j + \sum_{k \neq j} \beta_k g_k + \gamma T_j + \delta X_{hj} + \varepsilon_{hj} \tag{90b}$$

In (90b) the coefficients β_k are the estimates of the marginal willingess to pay for the spillover benefits, $\text{DE}^j_{g_k}$. The summation of neighboring policies could also take a weighted average of the policies if identifying the effect of many jurisdictions is difficult.

6.7 What Welfare Weights Are Used for the Social Planner?

Estimating the SMVPF requires taking a stance on the weight that the federal planner assigns to each jurisdiction. As discussed in Section 4.3, even in the absence of direct spillover benefits with ownership of firms and profits throughout the federation, local policies will affect resident utility in other jurisdictions via general equilibrium effects on prices and wages. This necessitates assigning welfare weights for jurisdictions throughout the federation.

How might these welfare weights be chosen? Hendren (2020) offers one approach, "inverse-optimum weights". Intuitively, Hendren (2020) argues that we might infer the welfare weights chosen by policy makers via observation of what is presumably an optimal policy. In Hendren (2020), this policy is federal income tax code.

The logic behind Hendren's approach to inferring these optimal welfare weights is straightforward: to determine the welfare weight associated with a particular income (y) determine how much it costs to give that group a tax cut of 1, $g(y)$. Absent any behavioral effects of tax cut the cost is simply \$1. However, the tax cut is likely to change behavior – those with incomes below y may increase their labor efforts to obtain the cut while those with income above y may reduce labor efforts. Then $g(y) = 1 + FE$ where FE is the fiscal externality associated with tax cut.

How, then, are the optimal social welfare weights obtained? From Hendren (2020) (p. 4) the (first order) conditions for optimal social welfare weights can be expressed as

$$\frac{\chi^*(y)}{g(y)} = \kappa, \ \forall \ y \tag{91}$$

From (91) it follows that the social welfare weight associated with income of (y), $\chi^*(y)$, is inversely related to the cost of providing those with income y a tax cut of \$1. And the ratio must equal a constant, κ.

One approach Hendren follows to operationalizes this measure employs estimates of taxable income elasticities. Following this approach Hendren estimates \$1 tax cut for high incomes has costs about \$0.65 while at the lower end of the income distribution a tax cut (expansion in EITC) cost about \$1.15, Then based on (91), the social welfare weight on low income households is 1.77 times greater than that for the high income household.

Hendren (2020)'s application determines social welfare weights for individual households of differing income. Our interest, however, is not in comparing welfare across individuals but across jurisdiction as required to determine the $SMVPF$ in (39). One way of extending Hendren (2020)'s approach to welfare weights for jurisdictions is to assume local populations are relatively homogeneous and to obtain the welfare weights obtained by Hendren (2020) based on the average income in the jurisdiction, $\chi^{*}\left(\overline{y_i}\right)$ where $\overline{y_i}$ is the average income in the jurisdiction. Alternatively, one could determine the average social welfare weight in the jurisdiction, $\int_{\underline{y}}^{\overline{y}} f(y)\chi^{i}\left(y\right)dy$ where $f(y)$ is the probability density function of the jurisdiction income distribution. This approach requires information on the distribution of income in the jurisdiction, and thus will be more of a data challenge.[13]

7 Empirical Application

In this section, we conduct a calibration exercise similar to Hendren and Sprung-Keyser (2020) taking estimates of various elasticities from the literature to estimate the LMVPF/SMVPF. To that aim, we plan to take off-the-shelf estimates of the effects of local K-12 school spending. There's a large literature on the sorting effects, house price effects, and long-run effects on kids (e.g. Jackson et al. 2016). Thus, we hope our paper will be a nice way to think about summarizing the results in that large literature and to highlight the resulting divergence of the LMVPF and SMVPF. As a second policy example, we plan to study the effect of state universities, in particular, because college students are highly mobile after graduation and college education likely has important spillover benefits. (Section to be completed.)

[13] Wildasin (1986) and Mirrlees (1972) demonstrate that individuals with equal incomes and levels of utility may have different marginal utilities of income ($\lambda_j(y)$). In their models, these differences arise because of spatial differences, which give rise to rent and commuting costs. More generally, differences in amenities and land rents will generate differences in $\lambda_j(y)$. These differences in $\lambda_j(y)$ across jurisdictions is not accounted for in the approach of Hendren (2020).

8 Conclusion

The MVPF has become a popular approach to empirical welfare analysis resulting from policies. One reason for this is that the MVPF provides clarity on what estimates are needed for welfare analysis. That is not to say that estimating all the components of the MVPF is easy. In particular, even in a closed economy setting, estimating the willingness to pay of a policy change can be challenging, especially for in-kind policies and policies that have effects on individuals not directly benefiting from the policy. The same is true for the local and social MVPFs we propose. For example, just like studying the effects on non-beneficiaries of policies is difficult, studying the effects on other jurisdictions is also challenging. An although not all parameters necessary to construct our MVPFs may be currently estimated (or convincingly estimated) in the literature, our MVPF derivations provide a way forward by making it clear to researchers what parameters are necessary or what assumptions are needed to ignore certain terms as negligible. We hope that our derivations will spur a new wave of policy research that focuses on interjursidictional externalities, measurement of the spillover benefits of public services, and the price effects of policies. We provide some guidance for estimating these effects, but readily acknowledge many others – especially structural modeling – may be useful to studying cross-jurisdictional issues.

Researchers have also been increasingly drawn to the use of "natural expirements" to identify causal effects. This often includes exploiting the staggered implementation of taxes or spending across states or localities (e.g., Fuest et al. 2018). Exploiting the staggered adoption of policies across states in empirical identification strategies is something that is generally only possible in federalist countries where states act as "laboratories" for policy innovation, but where administrative records are maintained centrally. Given this literature naturally exploits subnational policy changes, which inevitably have mobility, capitalization, and spillover effects, a next step is to convert the plethora of causal effects estimated using staggered policy adoptions to determine the welfare effects of these programs both locally and naturally. Our paper provides a comprehensive framework for this.

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Appendix

A Responses in the 2-jurisdiction case

A.1 Derivation of the responses

The population conditions (18) can be written as:

$$n_1 = \frac{N}{1+\exp(\mu \Delta V)} \tag{A.1}$$

$$n_1 + n_2 = N \tag{A.2}$$

where $\Delta V = V_2 - V_1$ and the indirect utility (7) is:

$$V_i = U\left(\frac{1}{1+t_i^x}[(1-t_i^\ell)w_i - t_i^n - p_i], g_i, g_{-i}\right) \qquad i = 1,2 \tag{A.3}$$

The equilibrium conditions reduce to condition (A.1) in which we plug $n_2 = N - n_1$ from (A.2). This condition implicitly defines the population of jurisdiction 1 n_1 as a function of the policy instrument set $\mathbf{P} = \{P_1, P_2\}$. Therefore, differentiating (A.1) with respect to policy instrument $\tau \in \mathbf{P}$, we obtain:

$$\frac{\partial n_1}{\partial \tau} = -\frac{\mu n_1 n_2}{N}\left(\frac{\partial \Delta V}{\partial n_1}\frac{\partial n_1}{\partial \tau} + \frac{\partial \Delta V}{\partial \tau}\right) \qquad \text{so that,} \qquad \frac{\partial n_1}{\partial \tau} = -\frac{\mu \dfrac{\partial \Delta V}{\partial \tau}}{\dfrac{N}{n_1 n_2} + \mu \dfrac{\partial \Delta V}{\partial n_1}} \tag{A.4}$$

from which it follows that:

$$\frac{\partial n_1}{\partial t_1^n} = -\frac{\mu n_1 n_2\,(1+t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{A.5}$$

$$\frac{\partial n_1}{\partial t_1^\ell} = -\frac{\mu n_1 n_2 w_1 (1+t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{A.6}$$

$$\frac{\partial n_1}{\partial t_1^x} = -\frac{\mu n_1 n_2 x_1 (1+t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{A.7}$$

$$\frac{\partial n_1}{\partial g_1} = \frac{\mu n_1 n_2 (1+t_1^x)(1+t_2^x)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right) \qquad > 0, \tag{A.8}$$

where

$$D \equiv n_1 n_2 \left[\mu \sum_{i=1,2} \left(1 + t^x_{-i}\right) \frac{\partial U_i}{\partial x_i} \left((1 + t^h_i) \frac{\partial p_i}{\partial n_i} - (1 - t^\ell_i) \frac{\partial w_i}{\partial n_i} \right) + \frac{N(1+t^x_1)(1+t^x_2)}{n_1 n_2} \right] > 0$$

whose sign directly follows from assumption (49).

Let us turn to the responses of the consumption x_i to policy changes. Inserting (A.5)–(A.8) into (53) we obtain:

$$\frac{\partial x_1}{\partial t^n_1} = -\frac{1}{D} \left(N(1+t^x_2) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \right) \quad <0 \tag{A.9}$$

$$\frac{\partial x_1}{\partial t^\ell_1} = -\frac{w_1}{D} \left(N(1+t^x_2) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \right) \quad <0 \tag{A.10}$$

$$\frac{\partial x_1}{\partial t^x_1} = -\frac{x_1}{D} \left(N(1+t^x_2) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \right) \quad <0 \tag{A.11}$$

$$\frac{\partial x_1}{\partial g_1} = \frac{\mu n_1 n_2 \left(1+t^x_2\right)}{D} \left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1} \right) \left((1-t^\ell_1) \frac{\mathrm{d}w_1}{\mathrm{d}n_1} - \frac{\mathrm{d}p_1}{\mathrm{d}n_1} \right) \tag{A.12}$$

the last response implies that:

$$\mathrm{sign} \left(\frac{\partial x_1}{\partial g_1} \right) = \left((1-t^\ell_1) \frac{\mathrm{d}w_1}{\mathrm{d}n_1} - \frac{\mathrm{d}p_1}{\mathrm{d}n_1} \right) \tag{A.13}$$

since $\frac{\partial U_1}{\partial g_1} > \frac{\partial U_2}{\partial g_1}$. Similarly, we obtain the cross-effects:

$$\frac{\partial x_2}{\partial t^n_1} = \frac{\mu n_1 n_2 \frac{\partial U_1}{\partial x_1}}{D} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \tag{A.14}$$

$$\frac{\partial x_2}{\partial t^\ell_1} = \frac{\mu n_1 n_2 w_1 \frac{\partial U_1}{\partial x_1}}{D} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \tag{A.15}$$

$$\frac{\partial x_2}{\partial t^x_1} = \frac{\mu n_1 n_2 x_1 \frac{\partial U_1}{\partial x_1}}{D} \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \tag{A.16}$$

$$\frac{\partial x_2}{\partial g_1} = -\frac{\mu n_1 n_2 \left(1+t^x_1\right)}{D} \left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1} \right) \left((1-t^\ell_2) \frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2} \right) \tag{A.17}$$

It follows that:

$$\text{sign}\left(\frac{\partial x_2}{\partial t_1^n}\right) = \text{sign}\left((1-t_2^\ell)\frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2}\right) \tag{A.18}$$

$$\text{sign}\left(\frac{\partial x_2}{\partial t_1^\ell}\right) = \text{sign}\left((1-t_2^\ell)\frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2}\right) \tag{A.19}$$

$$\text{sign}\left(\frac{\partial x_2}{\partial t_1^x}\right) = \text{sign}\left((1-t_2^\ell)\frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2}\right) \tag{A.20}$$

$$\text{sign}\left(\frac{\partial x_2}{\partial g_1}\right) = -\text{sign}\left((1-t_2^\ell)\frac{\mathrm{d}w_2}{\mathrm{d}n_2} - \frac{\mathrm{d}p_2}{\mathrm{d}n_2}\right) \tag{A.21}$$

From conditions (A.5)–(A.21), it follows that in the case of household immobility, i.e. $\mu \to 0$,we have:

$$\frac{\partial n_1}{\partial t_1^n} \to 0 \qquad \frac{\partial n_1}{\partial t_1^\ell} \to 0 \qquad \frac{\partial n_1}{\partial t_1^x} \to 0 \qquad \frac{\partial n_1}{\partial g_1} \to 0 \tag{A.22}$$

$$\frac{\partial x_1}{\partial t_1^n} \to -\frac{1}{1+t_1^x} < 0 \qquad \frac{\partial x_1}{\partial t_1^\ell} \to -\frac{w_1}{1+t_1^x} < 0 \qquad \frac{\partial x_1}{\partial t_1^x} \to -\frac{x_1}{1+t_1^x} < 0 \qquad \frac{\partial x_1}{\partial g_1} \to 0 \tag{A.23}$$

$$\frac{\partial x_2}{\partial t_1^n} \to 0 \qquad \frac{\partial x_2}{\partial t_1^\ell} \to 0 \qquad \frac{\partial x_2}{\partial t_1^x} \to 0 \qquad \frac{\partial x_2}{\partial g_1} \to 0, \tag{A.24}$$

A.2 MVPF comparisons

The responses to tax and public good provision changes derived in this appendix are summarized in Tables A.1 and A.2. This allows to compare the local MVPF to the closed economy MVPF and to the social MVPF. Two polar cases allow to order these MVPFs unambiguously.

$$
\begin{aligned}
CMVPF_{\tau_i} &= \frac{\text{DE}_{\tau_i}}{\text{ME}_{\tau_i} + \text{BE}^i_{\tau_i}} \\
LMVPF_{\tau_i} &= \frac{\text{DE}_{\tau_i} + \text{IE}^i_{\tau_i}}{\text{ME}_{\tau_i} + \text{BE}^i_{\tau_i} + \text{PMC}^i_{\tau_i}} \\
SMVPF_{\tau_i} &= \frac{(\text{DE}_{\tau_i} + \text{IE}^i_{\tau_i}) + (\text{DE}^j_{\tau_i} + \text{IE}^j_{\tau_i})}{(\text{ME}_{\tau_i} + \text{BE}^i_{\tau_i} + \text{PMC}^i_{\tau_i}) + (\text{BE}^j_{\tau_i} + \text{PMC}^j_{\tau_i})}
\end{aligned}
$$

where the direct effect $\text{DE}^j_{\tau_i}$ is as defined in equations (27) and (30) and the mechanical effect ME_{τ_i} is as defined in equation (33). Let:

$$
\begin{aligned}
\text{IE}^j_{\tau_i} &= n_j \left((1 - t^\ell_j) \frac{\partial w_j}{\partial \tau_i} - (1 + t^h_j) \frac{\partial p_j}{\partial \tau_i} \right) \\
\text{PMC}^j_{\tau_i} &= -n_j \left(t^\ell_j \frac{\partial w_j}{\partial \tau_i} + t^h_j \frac{\partial p_j}{\partial \tau_i} \right) - \left(r_j - \frac{\partial c_j}{\partial n_i} \right) \frac{\partial n_j}{\partial \tau_i} \\
\text{BE}^j_{\tau_i} &= -n_j t^x_j \frac{\partial x_j}{\partial \tau_i}
\end{aligned}
$$

Suppose first that private and public agglomeration economies are high:

$$
0 < (1 + t^h_i) \frac{\partial p_i}{\partial n_i} < (1 - t^\ell_i) \frac{\partial w_i}{\partial n_i} \qquad\qquad \frac{\partial c_i}{\partial n_i} < r_i.
$$

In this case, from columns 8 and 16 of Table A.1, we have, for $j \neq i$:

$$
\text{IE}^i_{t^b_i} < 0, \qquad \text{PMC}^i_{t^b_i} > 0, \qquad \text{DE}^j_{t^b_i} = 0, \qquad \text{IE}^j_{t^b_i} > 0, \qquad \text{BE}^j_{t^b_i} < 0, \qquad \text{PMC}^j_{t^b_i} < 0,
$$

It follows that $LMVPF_{t^b_i} < CMVPF_{t^b_i}$ and $LMVPF_{t^b_i} < SMVPF_{t^b_i}$. From columns 8 and 16 of Table A.2, we have, for $j \neq i$:

$$
\text{IE}^i_{g_i} > 0, \qquad \text{PMC}^i_{g_i} < 0, \qquad \text{DE}^j_{g_i} > 0, \qquad \text{IE}^j_{g_i} < 0, \qquad \text{BE}^j_{g_i} > 0, \qquad \text{PMC}^j_{g_i} > 0,
$$

It follows that $LMVPF_{g_i} > CMVPF_{g_i}$ and $LMVPF_{g_i} > SMVPF_{g_i}$, assuming that in the positive spillover effect $\text{DE}^j_{g_i} > 0$ is small compared to the negative disposable income effect.

Suppose now that the marginal product of labor is strongly decreasing and public agglomeration economies are low:

$$t_i^\ell \frac{\partial w_i}{\partial n_i} < -t_i^h \frac{\partial p_i}{\partial n_i} < 0 \qquad\qquad \frac{\partial c_i}{\partial n_i} > r_i$$

In this case, from columns 1 and 9 of Table A.1, we have, for $j \neq i$:

$$\text{IE}^i_{t_i^b} > 0, \qquad \text{PMC}^i_{t_i^b} < 0, \qquad \text{DE}^j_{t_i^b} = 0, \qquad \text{IE}^j_{t_i^b} < 0, \qquad \text{BE}^j_{t_i^b} > 0, \qquad \text{PMC}^j_{t_i^b} > 0,$$

It follows that $LMVPF_{t_i^b} > CMPF_{t_i^b}$ and $SMVPF_{t_i^b} < LMVPF_{t_i^b}$ From columns 1 and 9 of Table A.2, we have, for $j \neq i$:

$$\text{IE}^i_{g_i} < 0, \qquad \text{PMC}^i_{g_i} > 0, \qquad \text{DE}^j_{g_i} > 0, \qquad \text{IE}^j_{g_i} > 0, \qquad \text{BE}^j_{g_i} < 0, \qquad \text{PMC}^j_{g_i} < 0,$$

It follows that $LMVPF_{g_i} < CMVPF_{g_i}$ and $LMVPF_{g_i} < SMVPF_{g_i}$.

Table A.1. Sign table for the oomponents of the MVPF with respect to t_i^b.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
		I. Responses															
		Local responses ($j = i$)								External responses ($j \neq i$)							
Public agglomeration economies		LOW				HIGH				LOW				HIGH			
Private agglomeration economies		VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH
Population	$\frac{\partial n_j}{\partial t_i^b}$	**−**	−	−	−	−	−	−	**−**	**+**	+	+	+	+	+	+	**+**
Wage	$\frac{\partial w_j}{\partial t_i^b}$	**+**	+	−	−	+	+	−	**−**	**−**	−	+	+	−	−	+	**+**
Rent	$\frac{\partial p_j}{\partial t_i^b}$	**−**	−	−	−	−	−	−	**−**	**+**	+	+	+	+	+	+	**+**
Consumption	$\frac{\partial x_j}{\partial t_i^b}$	**−**	−	−	−	−	−	−	**−**	**−**	−	−	+	−	−	−	**+**
		II. MVPF															
		LMVPF ($j = i$)								EMVPF ($j \neq i$)							
Public agglomeration economies		LOW				HIGH				LOW				HIGH			
Private agglomeration economies		VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH
A. Numerator																	
DE_{ij}	$\text{DE}^j[t_i^b]$	**−**	−	−	−	−	−	−	**−**	**0**	0	0	0	0	0	0	**0**
$W_{ij} + R_{ij}$	$(1-t_j^\ell)n_j\frac{\partial w_j}{\partial t_i^b} - (1+t_j^h)n_j\frac{\partial p_j}{\partial t_i^b}$	**+**	+	+	−	+	+	+	**−**	**−**	−	−	+	−	−	−	**+**
B. Denominator																	
ME_{ij}	$\text{ME}_{t_i^b}$	**−**	−	−	−	−	−	−	**−**	**0**	0	0	0	0	0	0	**0**
B_{ij}	$-n_j t_j^x \frac{\partial x_j}{\partial t_i^b}$	**+**	+	+	+	+	+	+	**+**	**+**	+	+	−	+	+	+	**−**
P_{ij}	$-n_j\left(t_j^h\frac{\partial p_j}{\partial t_i^b} + t_j^\ell\frac{\partial w_j}{\partial t_i^b}\right)$	**−**	+	+	+	−	+	+	**+**	**+**	−	−	−	+	−	−	**−**
$M_{ij} + C_{ij}$	$\left(\frac{\partial c_j}{\partial n_j} - r_j\right)\frac{\partial n_j}{\partial t_i^b}$	**−**	−	−	−	+	+	+	**+**	**+**	+	+	+	−	−	−	**−**

NOTE— For private agglomeration economies, VLOW (very low) means $t_i^\ell\frac{\partial w_i}{\partial n_i} < -t_i^h\frac{\partial p_i}{\partial n_i} < 0$, LOW (low) means $-t_i^h\frac{\partial p_i}{\partial n_i} < t_i^\ell\frac{\partial w_i}{\partial n_i} < 0 < (1+t_i^h)\frac{\partial p_i}{\partial n_i}$, MED (medium) means $0 < (1-t_i^\ell)\frac{\partial w_i}{\partial n_i} < (1+t_i^h)\frac{\partial p_i}{\partial n_i}$ and HIGH (high) means $0 < (1+t_i^h)\frac{\partial p_i}{\partial n_i} < (1-t_i^\ell)\frac{\partial w_i}{\partial n_i}$. For public agglomeration economies, LOW (low) means $\frac{\partial c_i}{\partial n_i} > r_i$ and HIGH (high) means $\frac{\partial c_i}{\partial n_i} < r_i$.

Table A.2. Sign table for the oomponents of the MVPF with respect to g_i.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
		I. Responses															
		Local responses ($j = i$)								External responses ($j \neq i$)							
Public agglomeration economies		LOW				HIGH				LOW				HIGH			
Private agglomeration economies		VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH
Population	$\frac{\partial n_j}{\partial g_i}$	**+**	+	+	+	+	+	+	**+**	**−**	−	−	−	−	−	−	**−**
Wage	$\frac{\partial w_j}{\partial g_i}$	**−**	−	+	+	−	−	+	**+**	**+**	+	−	−	+	+	−	**−**
Rent	$\frac{\partial p_j}{\partial g_i}$	**+**	+	+	+	+	+	+	**+**	**−**	−	−	−	−	−	−	**−**
Consumption	$\frac{\partial x_j}{\partial g_i}$	**−**	−	−	+	−	−	−	**+**	**+**	+	+	−	+	+	+	**−**
		II. MVPF															
		LMVPF ($j = i$)								EMVPF ($j \neq i$)							
Public agglomeration economies		LOW				HIGH				LOW				HIGH			
Private agglomeration economies		VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH	VLOW	LOW	MED	HIGH
A. Numerator																	
DE_{ij}	$\text{DE}^j_{g_i}$	**+**	+	+	+	+	+	+	**+**	**+**	+	+	+	+	+	+	**+**
$W_{ij} + R_{ij}$	$(1-t^\ell_j)n_j\frac{\partial w_j}{\partial g_i} - (1+t^h_j)n_j\frac{\partial p_j}{\partial g_i}$	**−**	−	−	+	−	−	−	**+**	**+**	+	−	−	+	+	−	**−**
B. Denominator																	
ME_{ij}	ME_{g_i}	**+**	+	+	+	+	+	+	**+**	**0**	0	0	0	0	0	0	**0**
B_{ij}	$-n_j t^x_j \frac{\partial x_j}{\partial g_i}$	**+**	+	+	−	+	+	+	**−**	**−**	−	−	+	−	−	−	**+**
P_{ij}	$-n_j\left(t^h_j\frac{\partial p_j}{\partial g_i} + t^\ell_j\frac{\partial w_j}{\partial g_i}\right)$	**+**	−	−	−	+	−	−	**−**	**−**	+	+	+	−	+	+	**+**
$M_{ij} + C_{ij}$	$\left(\frac{\partial c_j}{\partial n_j} - r_j\right)\frac{\partial n_j}{\partial g_i}$	**+**	+	+	+	−	−	−	**−**	**−**	−	−	−	+	+	+	**+**

NOTE— For private agglomeration economies, VLOW (very low) means $t^\ell_i\frac{\partial w_i}{\partial n_i} < -t^h_i\frac{\partial p_i}{\partial n_i} < 0$, LOW (low) means $-t^h_i\frac{\partial p_i}{\partial n_i} < t^\ell_i\frac{\partial w_i}{\partial n_i} < 0 < (1+t^h_i)\frac{\partial p_i}{\partial n_i}$, MED (medium) means $0 < (1-t^\ell_i)\frac{\partial w_i}{\partial n_i} < (1+t^h_i)\frac{\partial p_i}{\partial n_i}$ and HIGH (high) means $0 < (1+t^h_i)\frac{\partial p_i}{\partial n_i} < (1-t^\ell_i)\frac{\partial w_i}{\partial n_i}$. For public agglomeration economies, LOW (low) means $\frac{\partial c_i}{\partial n_i} > r_i$ and HIGH (high) means $\frac{\partial c_i}{\partial n_i} < r_i$.