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 with benefit-spillovers, firm mobility, and household mobility effects from changing taxes and expenditures among interacting local jurisdictions. We then derive how mobility and spillovers influence the marginal value of public funds (MVPF). Because a federal planner internalizes interjurisdictional externalities, the MVPF for a federal and local planner can diverge substantially, and we derive theoretical conditions for when the local MVPF will be the larger or the smaller. 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. Finally, we illustrate the key differences of social and local MVPFs using empirical applications to decentralized wealth taxation, bidding-for-firm subsidy competition, and education spending.

Keywords: marginal value of public funds, fiscal competition, fiscal externalities, welfare, spillovers, mobility.

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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. In particular, 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 – is a useful and transparent framework to map causal effects to welfare analysis. 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 the MVPF 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, firms 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 effects 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 are critical to shaping how local governments make policy, but the 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. Therefore, 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 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 spillovers, mobility, and capitalization to obtain a measure of the MVPF. Our model features multi-tiered governments common to decentralized federations around the world, allowing us to derive the causal effects 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 is biased when not accounting for spillover and mobility effects. Our model allows us to generalize the applicability of the MVPF, and cost-benefit analysis more generally, to a variety of important decentralized policies.

The marginal value of public funds is the ratio of the marginal benefit to the marginal cost. While we generally talk about a policy that is costly, the MVPF applies to policies that might be budgetary beneficial (e.g., increase in income tax rate). The MVPF is traditionally operationalized as the willingness to pay for a beneficiary 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 response from the policy on own-government net budget outlays.

To define the MVPF in a federal system, we first need to specify "whose MVPF?" — that of 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 residents and the net cost on the own-jurisdiction government budget. As a result, the local government only accounts for mobility in so much as it affects its budget. 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 policies 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 composed of the willingness to pay and the net cost to a nearby jurisdiction resulting from a competitor jurisdiction changing its policy. For example, education spending may benefit nonresidents, but may also induce sorting out of nearby jurisdictions that alter wages, prices, and the cost of providing public services there.

If these spillovers are global in nature (environmental protection of airborne pollutants), then these spillover on 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 jurisdictions.

Given these external effects, we then consider the MVPF of a federal planner who accounts for spillovers. In particular, one may be interested in evaluating the overall effect of a local 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). 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 willingness to pay for all other jurisdictions in the economy. Finally, the net cost to the government is the cost in jurisdiction i plus the interjurisdictional fiscal externality inclusive of congestion costs imposed on all other jurisdictions. We then show how the SMVPF can be converted from dollars into a welfare metric by multiplying by a weighted average of each locality's marginal utility of income.

Thus, in a federal system, the form of the MVPF remains the same, 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 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. But, in addition, open economy concerns imply that there are four novel channels by which the marginal cost is affected by the policy. First, the policy change results in mobility. Mobility of firms and peoples alters the fiscal bases and revenues of the jurisdiction from all taxing instruments paid by the household or the firm. Second, that mobility alters wages, housing rents and business profits across jurisdictions to restore spatial equilibrium and the changes in wages, rents and profits results in changes in 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. Third, because local public services can be congestible, changes in the number of residents or firms and thus the number beneficiaries from household or business public services, changes the costs of providing these services. Finally, the mobility of firms and changes in business inputs may alter the profitability of firms, thus affecting business profits and business tax revenue.

Each of the components of the local MVPF influences other jurisdictions. One jurisdiction's gain in terms of residents and firms 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.

Consider a specific example of 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 on the marginal cost of education. Furthermore, government revenue also changes as a result of capitalization into house prices or wages. Second, mobility into the jurisdiction also changes own-jurisdiction wages, house prices, and potentially profits, which alter the willingness to pay for more schooling. Depending on how education affects the labor market, the profitability of firms may change and firms may move to the jurisdiction; this affects business-tax revenue and the willingness to pay for education spending if firms are locally owned.

To determine the social MVPF, one must also consider the external effect on other jurisdictions. First, an increase in education spending by 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 migration from Boston, lowering tax revenue in Boston. In addition, this mobility also affects equilibrium wages, rents and potentially the number of firms and profits in Boston, also influencing the revenue there. Any revenue losses from mobility might be muted somewhat by a decline in the costs of providing goods because fewer residents and businesses must be serviced in Boston. Second, and likely the case for many municipal public services, increasing education spending in Cambridge induces positive spillover benefits on other individuals outside of the jurisdiction by making them more productive. Even without directly consuming education services in Cambridge, education spending there may raise the productivity of Boston residents if there are productivity spillovers, or if some residents from Boston commute to Cambridge. 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 Boston.

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.

Against this backdrop, we show that when people are immobile, then under the same assumptions as the prior literature, wages and housing rents are constant and the MVPF reduces to that in Hendren (2016). Mobility and spillovers complicate 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 willingness to pay of nonresidents, the mobility elasticity, as well as measures of capitalization, but these are all parameters that are often estimated in the local public finance literature. We provide empirical guidance on how to select these parameters along with thoughts about which parameters are missing in the literature.

Our derivation of the MVPF is quite general, further expanding the literature to include business public services, business taxes, and property taxes. 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), but without not assuming specific functional forms. 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 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 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 (local) MVPF, the LMVPF, and the SMVPF? For a two-jurisdiction economy in which the individual housing demand, labor supply, and the number of businesses are fixed but workers are mobile, we show that this ranking critically depends on the relative strength of agglomeration and dispersion forces.

If public and private agglomeration forces are high, the local MVPF of increasing education spending that "wrongly" ignores open economy considerations underestimates the "true" local MVPF.[1] By attracting new residents, public services provision strongly increases the local wage and the residents' disposable income. So, the willingness to pay for the policy accounted for by the "true" local MVPF is higher than that accounted for by the MVPF which ignores capitalization effects. As to the net government costs, the jurisdiction benefits from more property and labor tax revenues due to the wage and housing price increase. Also, each new resident brings more tax revenues than she increases the cost of public services provision, if the public services are subject to agglomeration economies as well. Thus, the net cost to government of the "true" local MVPF is higher than that of the MVPF which ignores mobility and capitalization.

Moreover, if agglomeration forces are relatively high and public good spillovers are small, the local MVPF overstates the social MVPF for the same reasons. Specifically, the local MVPF for public services ignores the fact that there are losses in the other jurisdiction as reduction in agglomeration from outflight of residents elsewhere lowers wages reducing the willingness to pay, and tax revenues decrease as residents leave and wages fall. If however, dispersion forces are high, the social MVPF becomes larger than the local MVPF. Here the extent of public good spillovers are critical. If public good spillovers are relatively high — as might be the case for education — then regardless of the agglomeration or dispersion forces, the local MVPF always understates the social MVPF, which accounts for the effects on nonresident utility due to benefit from the services.

A common theme in the local tax competition literature is that jurisdictions "bid" for firms by offering subsidy deals that consist of either business-tax breaks or the provision of added business public services by the locality. To study and compare the MVPFs of business policies, we also consider a two-jurisdiction specialization of our model focusing on firm inter-jurisdictional mobility. It highlights an asymmetric outcome of two types of business incentives — tax reduction and public service provision — in an open economy with important public service spillover effects. When cutting

[1] On the contrary, if dispersion forces are high, the reverse holds: the closed economy MVPF overestimates the local MVPF

its business tax rate, a jurisdiction essentially ignores the cost imposed on other jurisdictions which lose firms: the social MVPF is overstated by the local MVPF. However, when providing public services which entail important spillover effects, a jurisdiction mainly ignore social benefits to other jurisdictions: the social MVPF is understated by 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 in order to calculate the MVPF in a federation.

To illustrate these concepts, we conduct four calibration exercises where we calculate the closed-economy MVPF, LMVPF, and SMVPF. These include decentralized wealth tax cuts, subsidy competition for large firms like Amazon, and applications to K-12 and higher education. The example using bidding for firms is particularly noteworthy, as we argue that the structure of the bidding auction provides information on various components of the MVPF. The example of wealth taxes shows that while the social and local MVPF might be differently above or below one, both are qualitatively similar because decentralized taxation does not induce large mobility responses. On the other hand, the example of bidding indicates that a local planner may evaluate the MVPF to be ex ante infinite so that the bid pays for itself, but a social planner values the MVPF of the bid at near zero. Intuitively, in the case of bidding, the winner believes all the benefits of attracting the plant accrue to their state at no cost to others, while a social planner accounts for the fact that bidding simply transfers the fiscal benefits and employment from the runner-up to the winner. In this way, bidding is a zero sum game. The examples show the importance of answering "whose MVPF?" before analyzing the welfare effects of decentralized policymaking.

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

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

or alternatively,

$$MVPF = \frac{WTP}{1+FE},$$

where WTP 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 that 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

$$\eta_1 MVPF_1 \geq \eta_2 MVPF_2.$$

In this way, the MVPF quantifies the tradeoff society faces when 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 the 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 are a trivial share of tax revenue. In this way, the marginal cost of public funds varies across taxing instruments. An advantage, then, of the MVPF is breaking the link between spending and taxes.

The remainder of the paper is organized as follows. Section 2 introduces the general spatial equilibrium model sustaining our analysis. Section 3 describes the components of the MVPF. Section 4 contrasts the different concepts of MVPFs in a federation and states their link to social welfare. Section 5 builds on some specialization of our general model to make statements on the relative levels of the different MVPFs. Section 6 discusses how researchers can estimate our various MVPFs. Section 7 provides some empirical applications of MVPF calculation. Section 8 concludes.

2. A General Framework for MVPF in a Federation

In this section, we set up the necessary fundamentals to derive the MVPF in an open economy setting. The derivation of the MVPF is quite general and does not rely on any specific household structure or production structure. We sketch a spatial general equilibrium model which is in line with regional models like Kline and Moretti (2014), Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2019) in which individuals work in their 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. Importantly, contrary to these contributions, our model does not assume specific functional forms because the MVPF is independent of the model particular specification. As in the models mentioned above, one important theme of our model household and firm mobility, which has been argued to be critical at the state and local level.[2]

[2] 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).

2.1. Household Utility

The national economy consists of I jurisdictions (states or localities) indexed by $i = 1, \ldots, I$ 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.[3,4] 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:

$$U_i + e_i = U(x_i, \ell_i, h_i, \mathbf{g}) + e_i \tag{1}$$

where x_i is the consumption of a freely tradeable, private numeraire good, ℓ_i is the amount of labor supplied, h_i is housing consumption, and $\mathbf{g} \equiv (g_1, \ldots, g_I)$ includes the amount of public goods/services g_j provided by all jurisdictions $j = 1, \ldots, I$ in the economy.[5] Due to expenditure spillovers (Case et al., 1993), residents of i benefit from the public goods provided not only by their own jurisdiction g_i but also by the other jurisdictions $(g_1, \ldots, g_{i-1}, g_{i+1}, \ldots, g_I)$. 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 $\partial U_i/\partial g_i > \partial U_j/\partial g_i \geq 0$, for all $j \neq i$ which means that local public goods marginally provide more satisfaction to local residents than to residents of neighboring jurisdictions.

All jurisdictions i raise revenue from the same taxes: a commodity tax, an income tax, a property tax, business taxes 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, we include business taxes, given the importance of bidding for firms and subsidy competition for state and local governments. For purposes of our initial model, income taxes follow the residence

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[3] Their role of these idiosyncratic preferences for jurisdictions is to allow households' inter-jurisdictional mobility to be imperfect, so that in the equilibrium the utility levels are not the same in all jurisdictions. This implies a divergence between a jurisdiction's welfare and the social welfare, which is key to understand how the local MVPF differs from the social MVPF.

[4] The distribution of e_i can be whatever as our general MVPF formulas only requires mobility of the agents and does not depend on the type or degree of this mobility. However, in some special cases considered later in section 5 a Gumbel distribution distribution will be used for illustration purposes.

[5] Of course, one might have $\partial U_i/\partial g_j = 0$ for some jurisdiction j which are spatially far away from i.

principle, commodity taxes follow the destination principle, and business taxes follow the source principle. We subsequently discuss how each of these sourcing rules can be relaxed.

The price of housing is p_i and the wage rate is w_i in jurisdiction i. In addition to labor earnings received in their jurisdiction of residence, individuals also receive residual profits from the production of the private numéraire good and housing. 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. Then, the household budget constraint is:

$$(1 + t_i^h)p_i h_i + (1 + t_i^x)x_i = y_i + (1 - t_i^\ell)w_i \ell_i - t_i^n \tag{2}$$

where t_i^h is the ad valorem property taxes for the state, t_i^x is the ad valorem commodity tax, t_i^ℓ is the ad valorem labor tax and t_i^n is a head tax, which also acts as a possible government expenditures via cash transfer.

Each 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 (2). This yields Marshallian demands and supply functions, $x_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g})$, $h_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g})$ and $\ell_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g})$, where $\mathbf{t}_i = \left(t_i^x, t_i^h, t_i^\ell, t_i^n,\right)$, the vector of household taxes in jurisdiction i and $\mathbf{g} = (g_i, \mathbf{g}_{-i})$ is the vector of public goods provided in the economy. Inserting the Marshallian demands into (1) defines the indirect utility function

$$V_i + e_i = V_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}) + e_i \tag{3}$$

In the locational equilibrium, the individual will choose to live and work in the jurisdiction yielding the highest utility.

2.2. Businesses

In jurisdiction i, m_i identical firms produce the numéraire good. The production technology for the firm is denoted by the function $f_i\left(l_i, L_i, \mathbf{z}\right) + \epsilon_i$ where l_i is the labor employed by each firm, $L_i \equiv m_i l_i$ is total employment in i and $\mathbf{z} = (z_1, \ldots, z_I)$ denotes the vector of public investments (infrastructure, for example). The parameter ϵ_i represents a firms' idiosyncratic jurisdiction-specific added productivity that is assumed, for simplicity, not to be subject to profit taxation.[6] One possible justification is that this idiosyncratic component is unobserved to the jurisdiction or represents non-

[6] Again, the distribution of ϵ_i does not matter to derive our general MVPF formulas, as discussed in footnote 4.

taxable output, but perhaps more realistically, this idiosyncratic part represents jurisdiction-specific non-deductible costs. 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 $\partial^2 f_i/\partial l_i^2 < 0$. Production of each firm in jurisdiction i is positively affected by public investments in both jurisdiction i, i.e. $\partial f_i/\partial z_i > 0$, and as a result of possible spillovers resulting from investment made by neighboring jurisdictions, i.e. $\partial f_i/\partial z_j \geq 0,\ j \neq i$. 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. $\partial^2 f_i/\partial L_i \partial l_i$. The net profit of a firm is:

$$(1 - t_i^{\pi})\pi_i + \epsilon_i = (1 - t_i^{\pi})[f_i(l_i, L_i, \mathbf{z}) - w_i l_i] + \epsilon_i, \tag{4}$$

where t_i^{π} is the profit tax (or subsidy) levied by jurisdiction i. Public business services and profit taxation are not present in Hendren (2016), which focuses on household policy instruments. In our framework, firms are inter-jurisdictionally mobile and local governments often "bid" for these firms (e.g., Black and Hoyt 1989; Mast 2019; Slattery 2020; Slattery and Zidar 2020), business tax policies are important are policy instruments doing so should be considered for the local MVPF.

The firm chooses its labor demand so as to maximize its profit function (4) taking the wage w_i, total employment L_i and the level of public services as given. This implies the first-order condition $\frac{\partial f_i}{\partial l_i}(l_i, L_i, \mathbf{z}) = w_i$. Inserting the definition of total labor employment $L_i = m_i l_i$ into the individual firm's first order condition and solving for l_i yields the firm labor demand $l_i(w_i, \mathbf{z})$ which does not depend on the profit tax t_i^{π}. Inserting the firms' labor demand functions into the profit expression, we obtain the individual firm's net profit function $(1-t_i^{\pi})\pi_i(w_i, \mathbf{z})+\epsilon_i$. In the locational equilibrium, the firm will choose to produce in the jurisdiction yielding the highest net profit.

2.3. Government Budgets

The government uses tax revenue to provide public services for its residents, g_i, but can also provide services for its businesses, z_i. 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:

$$G_i = c_i(g_i, z_i, \mathbf{n}, \mathbf{m}) - n_i\big(t_i^\ell w_i \ell_i + t_i^h p_i h_i + t_i^x x_i + t_i^n\big) - m_i t_i^\pi \pi_i \tag{5}$$

where $c_i = c_i(g_i, z_i, \mathbf{n}, \mathbf{m})$ denotes the cost function of producing public services from the private good x_i.[7] We denote $\mathbf{n} = (n_1, \ldots, n_I)$ as the vector of populations of all jurisdictions and $\mathbf{m} = (m_1, \ldots, m_I)$ as the vector of labor force in all jurisdiction. Critically, this general cost function allows for public services to be congestible as residents and firms move in and out of the jurisdiction. As a public service provided in i can be consumed by nonresidents, congestion can be induced by both residents and non residents. This is a very general specification as, assuming additive separability, $c_i = c_i^g(g_i, \mathbf{n}) + c_i^z(z_i, \mathbf{m})$, it allows for the case of pure public goods, $c_i^g(g_i, \mathbf{n}) = c_i(g_i)$, and publicly-provided private services, $c^g(g_i, \mathbf{n}) = c_i(g_i) \sum_j n_j$. Analogously, the same is true for business public services.

2.4. General Equilibrium

We can now characterize the equilibrium of the model. The housing and labor markets equilibria clearing conditions, in each jurisdiction i, are respectively:

$$n_i h_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}) = H_i(p_i), \tag{6a}$$

$$n_i \ell_i(p_i, w_i, y_i, \mathbf{t}_i, \mathbf{g}) = m_i l_i(w_i, \mathbf{z}), \tag{6b}$$

where $H_i(p_i)$ is the housing supply function which is increasing with respect to the housing rent. For later reference, denote $\pi_i^h(p_i)$ the (untaxed) profit of the housing production sector. Inter-jurisdictional mobility of households [firms] implies that the equilibrium number of residents [firms] in each jurisdiction i depends on the level of utility V_j [net profit $(1 - t_j^\pi)\pi_j$] in all the jurisdictions of the economy:

$$n_i = \Phi^n\Big(V_j(p_j, w_j, y_j, \mathbf{t}_j, \mathbf{g}_j)\ ;\ \forall j \in [1, I]\Big), \tag{7a}$$

$$m_i = \Phi^m\Big((1 - t_j^\pi)\pi_j(w_j, \mathbf{z})\ ;\ \forall j \in [1, I]\Big), \tag{7b}$$

where $\Phi^n(\cdot)$ and $\Phi^m(\cdot)$ are functions whose specific shapes depend on the distributions of the idiosyncratic terms e_i and ϵ_i. Finally, (part of) the profits generated in the economy accrue to the

[7] Our general formulation gathers specifications of the public cost function in many models: those with congestible public goods and mobile residents in which $c_i = c_i^g(g_i, n_i)$ (e.g. Wilson, 1995), models with congestible public input with mobile firms in which $c_i = c_i^z(z_i, m_i)$ (e.g. Matsumoto, 2000), and models with both which usually assume the additive form $c_i = c_i^g(g_i, n_i) + c_i^z(z_i, m_i)$ (e.g. Richter and Wellisch, 1996). Our specification also includes the case of public goods generating spillovers as modeled in Wellisch (1996) which considers a two-jurisdiction model in which the cost function $c_i = c_i^g(g_i, n_i, n_{-i})$.

residents as individual non-labor income, y_i, defined as:

$$y_i = \eta_i + \sum_j \left[(1-t_j^{\pi})m_j\pi_j\theta_i^j + \pi_i^h\theta_i^{hj}\right] \tag{8}$$

where η_i is a jurisdiction specific non-labor income, and θ_i^j and θ_i^{hj} are the exogenous profit shares of the firms producing the numeraire good and housing in j owned by the residents of jurisdiction i.[8] The equilibrium conditions (6a)–(7b) implicitly define, for each jurisdiction i, the equilibrium levels of the wage, $w_i^\star$, local housing rent $p_i^\star$, the population $n_i^\star$ and the number of firms $m_i^\star$, as a function of not only the levels of the policy instruments in jurisdiction i, $P_i = \left\{t_i^x, t_i^\ell, t_i^h, t_i^n, t_i^\pi, g_i, z_i\right\}$, but also those of all other jurisdictions $j \neq i$. Inserting the housing rent and wage equilibrium functions into the Marshallian demand and supply functions and the profit functions of the numeraire and housing sectors profit functions, we obtain, for each jurisdiction i, the equilibrium consumption of numeraire $x_i^\star$, housing consumption $h_i^\star$, labor supply $\ell_i^\star$, numeraire profit $\pi_i^\star$ and housing profit $\pi_i^{h\star}$.

In sum, the general equilibrium characterizes the levels, in each jurisdiction i, of the wage $w_i^\star \equiv w_i(\mathbf{P})$, the rent $p_i^\star \equiv p_i(\mathbf{P})$, the population $n_i^\star \equiv n_i(\mathbf{P})$, the number of firms $m_i^\star \equiv m_i(\mathbf{P})$, the numeraire consumption $x_i^\star \equiv x_i(\mathbf{P})$, the housing consumption $h_i^\star \equiv h_i(\mathbf{P})$, the labor supply $\ell_i^\star \equiv \ell_i(\mathbf{P})$, the numeraire profit $\pi_i^\star \equiv \pi_i(\mathbf{P})$ and the housing profit $\pi_i^{h\star} \equiv \pi_i^h(\mathbf{P})$ as a function of the aggregate policy instrument set $\mathbf{P} = (P_1, \ldots, P_I)$. The rest of the paper studies how a small policy change $\mathrm{d}\tau_i$ in jurisdiction i's policy instrument $\tau_i \in P_i$ determines a marginal value of public funds (MVPF) not only in jurisdiction i itself but also in all other jurisdictions of the economy. The responses to policy changes of all the equilibrium variables characterized in this section define the core component of the MVPFs.

3. The Components of the MVPF

This section describes the fundamental structure of the marginal value of public funds, or MVPF, in an open jurisdiction. Specifically, consider a policy $\mathrm{d}\tau_i$ consisting in a small change in the level of

[8] Allowing for heterogeneous local profit shares, θ_i^j and θ_i^{hj} owned by inter-jurisdictionally mobile individuals that are identical requires to implicitly assume that actually the firms are owned by the governments (the government of a locality possibly owns firms in other localities) which transfer the profits to their residents.

a policy instrument $\tau_i \in P_i$ of jurisdiction i.[9,10] The MVPF of this policy conducted in i measured in any open jurisdiction j of the economy (including i itself) is:

$$MVPF^j_{\tau_i} = \frac{WTP^j_{\tau_i}}{G^j_{\tau_i}} \tag{9}$$

that is, the ratio of the marginal willingness to pay for the policy of jurisdiction j's residents, denoted $WTP^j_{\tau_i}$ to the marginal budget deficit (or net cost) incurred by government j as result of the policy, denoted $G^j_{\tau_i}$. The MVPF is a measure of the welfare that can be provided to policy beneficiaries per dollar of government spending on the policy.

The main purpose of this section is to highlight that mobility and the capitalization effects it induces drastically shape the MVPF of an open jurisdiction, by altering both the willingness to pay and the government deficit induced by a policy. It introduces the main and basic claim of our paper: assessing the normative impact of a policy on an open locality requires an "open-MVPF" measure. To this aim, we systematically contrast our formulas with those derived in a closed-economy framework (Hendren, 2016; Hendren and Sprung-Keyser, 2020).

Before proceeding, we introduce some notation and terminology that will ease the exposition. Given that we consider a policy change initiated in jurisdiction i, $MVPF^i_{\tau_i}$, $WTP^i_{\tau_i}$, and $G^i_{\tau_i}$, are named "*local*" MVPF, "*local*" marginal willingness to pay and "*local*" marginal deficit, respectively. The same quantities measured in another jurisdiction $j \neq i$ are qualified as "*external*" and are denoted $MVPF^{j\neq i}_{\tau_i}$, $WTP^{j\neq i}_{\tau_i}$ and $G^{j\neq i}_{\tau_i}$. In other words, the *local* values correspond to the jurisdiction enacting the policy while the *external* values correspond to the effects on other jurisdictions. Finally, the general notations $MVPF^j_{\tau_i}$, $WTP^j_{\tau_i}$ and $G^j_{\tau_i}$ mean that jurisdiction j can either be itself, i, or another jurisdiction.

3.1. Local and External Marginal Willingness to Pay

The numerator of the MVPF in jurisdiction j of a small policy change $\mathrm{d}\tau_i$ in jurisdiction i is the marginal willingness to pay, $MWP^j_{\tau_i}$ which measures how much the n_j current residents of

[9] Of course, many policy changes are large but the focus on marginal policy changes allows to apply the envelope theorem, simplify the MVPF and highlight the key additional parameters necessary when estimating the welfare effects of policies in an open economy. Hendren and Sprung-Keyser (2020) and Kleven (2021) describes the modification necessary to move adapt marginal welfare measures, in particular the MVPF, to discrete policy changes.

[10] Hereafter, we consider the MVPF resulting from a change, $\mathrm{d}\tau_i$, in one of the policy instruments explicitly modeled in the paper. However, the formulas derived in the paper can be easily adapted to consider the MVPF resulting from any exogenous change (e.g. policy) $\mathrm{d}\xi_i$ occurring in jurisdiction i.

jurisdiction j are willing to pay for jurisdiction i to increase τ_i by one unit. For example, if $\mathrm{d}\tau_i$ is a schooling expenditure, $WTP^j_{\tau_i}/n_j$ is the amount of dollar that one resident of j is ready to pay for government i to spend \$1 extra dollar in schooling. More generally, the marginal willingness to pay for the policy is defined as $WTP^j_{\tau_i} \equiv (n_j/\lambda_j)\partial V_j/\partial \tau_i$, where $\lambda_j \equiv \partial V_j/\partial y$ is the marginal utility of income of the residents of jurisdiction j.[11] This is a measure in dollar terms of the marginal welfare entailed by one additional monetary unit of the policy: the higher the welfare generated by the policy, the more the individuals are willing to pay for it. To derive an intuitive and empirically operational expression of $WTP^j_{\tau_i}$, notice that using the individual budget constraint (2), the equilibrium level of the deterministic indirect utility (3) can be written as:

$$V^\star_j = U\left(\frac{1}{1+t^x_j}\left[y^\star + (1-t^\ell_j)w^\star_j\ell^\star_j - (1+t^h_j)p^\star_j h^\star_j - t^n_j\right], h^\star_j, \ell^\star_j, \mathbf{g}\right) \tag{10}$$

where the "star" superscripts indicate that the variable is a function of the policy vector $\mathbf{P}$ including τ_i, as defined in section 2.4. Differentiating (10) with respect to τ_i and applying the envelop theorem, we obtain the expression of the marginal willingness to pay of the residents of each j for τ_i:

$$WTP^j_{\tau_i} = \mathrm{DE}^j_{\tau_i} + \underbrace{(1-t^\ell_j)L_j\frac{\partial w_j}{\partial \tau_i} - (1+t^h_j)H_j\frac{\partial p_j}{\partial \tau_i}}_{\mathrm{IE}^j_{\tau_i}} + \mathrm{OE}^j_{\tau_i} \qquad \tau_i \in P_i \tag{11}$$

where $L_j = n_i\ell_j$ and $H_j = n_j h_j$ denote the labor supply and the housing consumption in the jurisdiction j, respectively. Condition (11) indicates that the effect of a marginal increase in the local instrument τ_i on welfare of residents includes three sub-effects described in the subsections below: the direct effect $\mathrm{DE}^j_{\tau_i}$, the disposable income effect $\mathrm{IE}^j_{\tau_i}$ and the profit ownership effect $\mathrm{OE}^j_{\tau_i}$.

The marginal willingness to pay (11) differs in two important respects compared to closed-economy MVPFs formulas derived in the earlier literature (Hendren, 2016). First, only the direct effect is present in closed-economy MVPFs formulas. The disposable income and ownership effects are mostly resulting from household and firm mobility. Second, and importantly, expression (11) generalizes the MVPF expressions derived in earlier literature to include inter-jurisdictional spillovers effects. Thus, prior literature ignored the external willingness to pay, i.e. $WTP^{j\neq i}_{\tau_i} = 0$, and only had a single jurisdiction concept.

[11] Expression (10) makes it clear that $\lambda_i = \frac{\partial V_i}{\partial y} = \frac{1}{1+t^x_i}\frac{\partial U_i}{\partial x_i}$, that is, one additional unit given to the resident of jurisdiction i allows her to consume $1/(1+t^x_i)$ units of the numeraire good and thus increases her utility by $1/(1+t^x_i) \times \partial U_i/\partial x_i$ units.

3.1.1. Direct Effect

The first effect that determines the marginal willingness to pay (11) is the *direct effect*. Its specific form depends on the policy instrument considered and whether the effect is in jurisdiction i or $j \neq i$:

$$\begin{cases} \text{DE}^{i}_{t^b_i} = -n_i \text{B}^b_i, \\ \text{DE}^{j\neq i}_{t^b_i} = 0, \end{cases} \quad (12a) \qquad \text{DE}^{j}_{t^\pi_i} = -n_j m_i \theta^i_j \pi_i, \quad (12b) \qquad \text{DE}^{j}_{g_i} = \frac{n_j}{\lambda_j}\frac{\partial U_j}{\partial g_i}, \quad (12c) \qquad \text{DE}^{j}_{z_i} = 0, \quad (12d)$$

where where $b = \ell, h, x, n$ indexes each household tax base, and $\text{B}^\ell_i = w_i \ell_i$, $\text{B}^h_i = p_i h_i$, $\text{B}^x_i = x_i$ and $\text{B}^n_i = 1$ are the tax bases per individual. Unlike other terms we will explore in the willingness to pay, the direct effects can be substantially different depending on whether they are local (own-jurisdiction) or external effects. Therefore, we describe them separately.

Let us start with the local marginal willingness to pay, $WTP^i_{\tau_i}$. First, (12a) and (12b) indicate that the direct effect of a tax, $\text{DE}^i_{t^b_i}$ and $\text{DE}^i_{t^\pi_i}$ are negative as expected: a unit increase in any tax reduces the income of an individual by the amount of her individual tax base. For, example, one unit increase in the labor tax t^ℓ_i (i.e. a 100% increase, as it is an ad valorem tax) reduces the individual's income by the amount of its labor income $w_i \ell_i$. Aggregating over the n_i residents of jurisdiction i, we obtain the expression of $\text{DE}^i_{t^\ell_i}$ in (12a). Second, (12c) indicates that the direct effect of public good provision $\text{DE}^i_{g_i}$ is positive as expected. Its expression is the well-know marginal rate of substitution between the public good and the numeraire good of i's resident, or equivalently, the sum of the marginal willingness to pay of the n_i residents of g_i for one extra unit of public good. Third, (12c) indicates that public inputs have no direct effect on individuals' willingness to pay; all their effects are through indirect effects on wages, rents and profits. The direct effects described above are similar to those derived in the Hendren's (2016) model.

Let us now turn to the external marginal willingness to pay, $WTP^{j\neq i}_{\tau_i}$. The most important difference with respect to the local WTPs is that, as can be seen in (12a), the household taxes of jurisdiction i entail no direct effect of the residents of jurisdiction $j \neq i$. The other external direct effects are similar to the local direct effects in functional form, but these effects now critically depend on whether spillovers of various nature exist in the economy or not. Unlike household taxes, (12b) indicates that jurisdiction i's profit tax has a direct negative effect on the WTP residents of jurisdiction j only if the latter own shares in the firms in jurisdiction i, i.e. $\theta^i_j > 0$. If "foreign" ownership is negligible, then this term approaches zero. Similarly, condition (12c) indicates that jurisdiction i's public good provision has a positive effect on the WTP of j's residents only if they directly enjoy i's public goods, i.e. $\partial U_j/\partial g_i > 0$. The less intensely nonresidents benefit from services, the smaller this effect will be. Of course, all these external direct effects are, by nature, not in the closed-economy MVPFs.

Noticeably, taxes do not have a direct effect on external governments. This is partially a result of the assumption that consumption taxes are destination-based and income taxes are residence-based, so that these taxes only affect residents of the jurisdiction. But, it is also a result of cross-border shopping and interjurisdictional commuting are being nonexistent in our model. It is easy to see that if these forces were added to the model, then the sourcing rules are critical. Even in the presence of these cross-border activities if taxes were destination-based and residence-based, then the external effects remain unchanged. However, if commodity taxes are levied at origin (the store location) and labor income taxes were paid to the state of employment, then non-residents benefit from sales and income taxes outside of their jurisdiction.[12] As a result of commuting and cross-border shopping, if jurisdiction i cuts these taxes, individuals living in a nearby jurisdiction j would have a positive direct effect of i's tax cuts on the external willingness to pay. This effect would be scaled by the number of individuals initially engaging in the cross-border activity, along with the share of labor income or consumption made abroad.

3.1.2. Disposable Income Effect

The second effect that determines the level of the marginal willingness to pay (11) is the *disposable income effect*. It has the same form, whatever the policy instrument $\tau_i \in P_i$, for all jurisdiction j (including i itself), but the sign and magnitude can differ across jurisdictions:

$$\mathrm{IE}^j_{\tau_i} \equiv (1-t^\ell_j)L_j\frac{\partial w_j}{\partial \tau_i} - (1+t^h_j)H_j\frac{\partial p_j}{\partial \tau_i}. \tag{13}$$

where $L_j = n_j\ell_j$ and $H_j = n_jh_j$. This effect results from the effect of price (wage and housing rent) changes on the individual disposable income $(1-t^\ell_i)w_i\ell_i - (1+t^h_i)p_ih_i$. These price changes may result either because of behavioral responses or because of mobility from policies. To the extent that the individual housing demand h_i and labor supply ℓ_i are relatively inelastic, the disposable income effect can essentially be interpreted as an indirect consequence of mobility as a result of price capitalization of the policy.[13]

[12] The state of employment or the state of the store location only cares about its own residents.

[13] For example, Hendren and Sprung-Keyser (2020) assume inelastic individual labor supply in the calculation of their MVPFs, eliminating general equilibrium effects. However, the empirical literature on capitalization via

As expression (13) suggests, the disposable income effect is an ambiguously signed effect on the WTP. Section 5 will describe in details the different economic forces which might increase or decrease the disposable income effect. However, one can already get much intuition by considering the example of a policy of a change in public good provision ($\mathrm{d}\tau_i = \mathrm{d}g_i$).

Consider first the disposable income effect of an increase in public goods by jurisdiction i on jurisdiction i's willingness to pay, $WTP^i_{g_i}$. Under a few reasonable assumptions, one might expect that the extra public goods attract new households to i. The added housing demand of these new residents exerts an upward pressure on the local housing rent p_i which reduces the disposable income of i's residents and thus their willingness to pay for the policy. In addition, the new resident in i also work there. Suppose that this increases the local wage w_i due to agglomeration economies.[14] This positive effect on the individual disposable income offsets the negative housing rent effect. Which of these two effects dominates is an empirical question.

The disposable income effect on the willingness to pay of another jurisdiction j, $WTP^{j\neq i}_{g_i}$, however, is qualitatively the opposite sign. As residents migrate from j to i, the rent decreases and the wage increases in j. Because many jurisdictions might see out-flows of migrants, the magnitudes of these effects on any one external jurisdiction may be small. Finally, notice that the disposable income effect is not present in closed-economy models that assume exogenous prices, consistent with the assumption of absence of mobility.

3.1.3. Ownership Effect

The last effect on the marginal willingness to pay is the *(profit) ownership effect* resulting from the change in profits received by the residents of j as i implements its policy. For each policy instrument $\tau_i \in P_i$, the ownership effect is:

$$\mathrm{OE}^j_{\tau_i} \equiv n_j \sum_k \left[(1 - t^\pi_k) \left(\pi_k \frac{\partial m_k}{\partial \tau_i} + m_k \frac{\partial \pi_k}{\partial \tau_i} \right) \theta^k_j + \frac{\partial \pi^h_k}{\partial \tau_i} \theta^{hk}_j \right]. \tag{14}$$

This effect, also not in Hendren (2016), is the effect of the policy on the return to assets (profits) of residents of the jurisdiction. It results not only from the change in the firms' profit but also from the location responses of the firms. If ownership is entirely absentee, that is, completely outside of

mobility indicates it is an important channel.

14 Section 5 shows that, alternatively, a decrease in w_i is also possible due to the decreasing marginal returns of labor.

the federal economy, then this term is zero.

An intuitive illustration of the ownership effect is the case of an increase in i's public input provision, $\mathrm{d}\tau_i = \mathrm{d}z_i > 0$. For simplicity, assume that housing is owned by absentee owners, i.e. $\forall j, k$, $\theta_j^{hk} = 0$ and all firms are owned locally, i.e. $\theta_j^k = 0$, for $k \neq j$. Under a few reasonable assumptions, the policy increases both the number of firms in i and their profits, so that the residents of i receive more income from profits and are thus willing to pay more for the policy to be implemented. The effect of the policy on $j \neq i$ is however likely to be ambiguous. The firm outflow from j to i reduces the profit received by j's residents. However, this outflow of firms is also likely to reduce the local wage and thus increase the local profit of j's firms, which increases the profit received by the residents. Again, which of these two effects dominates is an empirical question.

3.2. Local and External Marginal Budget Deficit

The denominator of the MVPF in jurisdiction j gives the effect of a policy change $\mathrm{d}\tau_i$ on the marginal budget deficit, $G^j_{\tau_i} \equiv \partial G_j / \partial \tau_i$. This measures the cost net of tax revenues of an increase of τ_i by one unit, accounting for general equilibrium responses of the economy. The equilibrium level of the budget deficit (5) of jurisdiction j can be written in vector form:[15]

$$G_j^\star = c\big(g_j, z_j, \mathbf{n}^\star, \mathbf{m}^\star\big) - n_j^\star \mathbf{t}_j \mathbf{q}_j^\star \mathbf{x}_j^\star - m_j^\star\, t_j^\pi\, \pi_j^\star. \tag{15}$$

where $\mathbf{t}'_j = (t_j^\ell \;\; t_j^h \;\; t_j^x \;\; t_j^n)$ is the household tax vector, $\mathbf{q}'_j = (w_j \;\; p_j \;\; 1 \;\; 1)$ is the price vector and $\mathbf{x}'_j = (\ell_j \;\; h_j \;\; x_j \;\; 1)$ is the consumption vector, as summarized in the notation Table A.1.[16] Differentiating (15), we obtain the local/external marginal deficit in jurisdiction j resulting from a small change in the policy instrument $\tau_i \in P_i$ of jurisdiction i:

$$G^j_{\tau_i} = \mathrm{ME}^j_{\tau_i} \underbrace{-n_j \mathbf{t}_j \mathbf{q}_j \frac{\partial \mathbf{x}_j}{\partial \tau_i}}_{\mathrm{BE}^j_{\tau_i}} \underbrace{-n_j \mathbf{t}_j \mathbf{x}_j \frac{\partial \mathbf{q}_j}{\partial \tau_i}}_{\mathrm{PE}^j_{\tau_i}} \underbrace{-m_j t_j^\pi \frac{\partial \pi_j}{\partial \tau_i}}_{\pi\mathrm{E}^j_{\tau_i}} + \underbrace{\left(\frac{\partial c_j}{\partial \mathbf{n}} \frac{\partial \mathbf{n}}{\partial \tau_i} - r_j \frac{\partial n_j}{\partial \tau_i}\right)}_{\mathrm{HME}^j_{\tau_i}} + \underbrace{\left(\frac{\partial c_j}{\partial \mathbf{m}} \frac{\partial \mathbf{m}}{\partial \tau_i} - t_j^\pi \pi_j \frac{\partial m_j}{\partial \tau_i}\right)}_{\mathrm{FME}^j_{\tau_i}} \tag{16}$$

where $r_j \equiv t_j^\ell w_j \ell_j + t_j^h p_j h_j + t_j^x x_j + t_j^n$ is the overall tax paid by a resident of j. Condition (16) indicates that the effect on the budget deficit of a marginal increase in the tax t_i^b can be decomposed

[15] Recall that the "star" superscript indicates that the equilibrium level of a variable is a function of the aggregate policy vector of the economy.

[16] $\partial \mathbf{v}/\partial y$ 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 $\mathbf{x}$. 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.

in four types of effects described in the subsections below: the mechanical effect $\text{ME}^j_{\tau_i}$, the behavior effect $\text{BE}^j_{\tau_i}$, the price and profit effects $\text{PE}^j_{\tau_i}$ and $\pi\text{E}^j_{\tau_i}$ and the mobility effects due to location decisions of households $\text{HME}^j_{\tau_i}$ and firms $\text{FME}^j_{\tau_i}$.

Only the mechanical and behavioral effects are present in MVPF formulas derived in earlier literature (Hendren, 2016). The other effects can be regarded as resulting essentially from household and firm mobility.[17] In addition, (16) includes not only the local marginal deficit of the policy $G^i_{\tau_i}$ considered in closed-economy models but also the external fiscal externality on other jurisdictions absent from this earlier literature, i.e. $G^{j\neq i}_{\tau_i} = 0$. In other words, due to mobility, the government budget on other jurisdictions may be affected.

3.2.1. Mechanical Effect

The first effect that determines the marginal deficit (11) is the *mechanical effect*. Like the direct effect on the WTP, the specific form of the mechanical effect depends on the policy instrument considered and whether the own-jurisdiction or external jurisdiction is being considered. The mechanical effects on the local marginal deficit, $G^i_{\tau_i}$, are:

$$\text{ME}^i_{t^b_i} = -n_i \text{B}^b_i, \quad (17a) \qquad \text{ME}^i_{t^\pi_i} = -m_i \pi_i, \quad (17b) \qquad \text{ME}^i_{g_i} = \frac{\partial c_i}{\partial g_i}, \quad (17c) \qquad \text{ME}^i_{z_i} = \frac{\partial c_i}{\partial z_i}, \quad (17d)$$

where $b = \ell, h, x, n$ indexes the household tax bases and the per capita tax bases B^b_i are as defined in (12). The mechanical effects on the external marginal deficit, $G^{j\neq i}_{\tau_i}$, are:

$$\text{ME}^{j\neq i}_{\tau_i} = 0. \qquad (17e)$$

The mechanical effect is the public budget counterpart of the direct effect on WTP (section 3.1.1). The local mechanical effects, $\text{ME}^i_{\tau_i}$, simply state that additional public good and input provision is costly, according to (17c) and (17d), and that an additional unit of any tax reduces the deficit by the size of the tax base, according to (17a) and (17b). Moreover, expression (17e) makes clear that none of the policy instruments of jurisdiction i entail a mechanical budgetary effect on jurisdiction j. The mechanical effects (17) are also present in closed-economy models (Hendren, 2016).

[17] The exception is the profit effect which, even considering immobile agents and thus exogenous prices, can be directly affected by public input changes. But the other policy instruments (the pure profit tax t^π_i included) would not affect the profit in this closed-economy framework.

3.2.2. Behavorial effect

The second effect is the *behavioral effect*, that is, the effect of households' changes in their consumption bundle and labor supply as a response on the government budget. For any policy $\mathrm{d}\tau_i$ with $\tau_i \in P_i$ implemented by jurisdiction i, the behavioral effect of jurisdiction j's marginal deficit is:[18]

$$\text{BE}^{j}_{\tau_i} \equiv -n_j \mathbf{t}_j \mathbf{q}_j \frac{\partial \mathbf{x}_j}{\partial \tau_i} = -n_j \left(t^x_j \frac{\partial x_j}{\partial \tau_i} + t^h_j p_j \frac{\partial h_j}{\partial \tau_i} + t^\ell_i w_j \frac{\partial \ell_j}{\partial \tau_i} \right) \tag{18}$$

The local behavioral effect $\text{BE}^{i}_{\tau_i}$ is present in closed-economy MVPF formulas (Hendren, 2016) and is also referred to as the "fiscal externality". Indeed, no mobility is required for, say, a tax to affect the consumption or labor supply choices of an individual, and thus change tax revenue.

However, mobility can explain important behavioral responses that closed-economy models misinterpret or simply ignore. The typical case is the behavioral effect of a change in housing consumption, say in i, as jurisdiction i increases its public good provision (e.g., schooling expenditure): $t^h_i \partial h_i / \partial g_i$.[19] Estimation of the local MVPF in i requires to find estimates of the response $\partial h_i / \partial g_i$. What level and sign would a closed-economy model ignoring mobility and capitalization predict for this estimate? Probably, not much: if a school is built in a jurisdiction, will residents consume bigger or smaller houses in the absence of inter-jurisdictional mobility and exogenous housing prices? There is no straightforward answer. Even worse, if we have in mind a Cobb-Douglas utility function of the type $U_i = x_i^a h_i^b \ell_i^c g_i^d$, the housing demand does not directly depend on public good consumption so that a closed-economy model would predict $\partial h_i^d / \partial g_i = 0$.[20]

On the contrary, the present open-economy model provides immediate intuition about this effect. Like any local amenity (Ahlfeldt et al., 2015), public good provision is likely to attract new residents resulting in positive housing price capitalization. One can therefore expect that this increase in housing rents spur the residents of i to reduce the housing consumption.

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[18] The head tax is independent of consumption and labor levels, and thus does not appear here.

[19] The two-jurisdiction example in section 5.2 shows that several other behavioral effects that would be particularly difficult to interpret in a closed-economy model, such as $\partial x_i / \partial g_i$, can easily be understood in an open-economy model.

[20] This is probably one of the reason why Hendren and Sprung-Keyser (2020) ignore property taxation, an thus the fiscal externality $t^h_j p_j \partial h_j / \partial g_i$, in all their MVPF estimates.

3.2.3. Price and Profit Effects

The third type of effects of the policy on the government's budget are general equilibrium effect affecting tax revenues through price and profit changes. The *price effects* on government j's budget deficit are:

$$\text{PE}^j_{\tau_i} \equiv -n_j \mathbf{t}_j \mathbf{x}_j \frac{\partial \mathbf{q}_j}{\partial \tau_i} = -n_j \left(t^\ell_j \ell_j \frac{\partial w_j}{\partial \tau_i} + t^h_j h_j \frac{\partial p_j}{\partial \tau_i} \right) \tag{19}$$

These price effects are the public budget counterparts of the disposable income effect on households' willingness to pay (section 3.1.2). They result from the ad valorem nature of the taxes which implies that changes in the wage [housing rent] affect the labor [property] tax base. These effects, which are not in Hendren (2016), might be viewed as resulting essentially from household mobility, if individual housing consumption and labor supply are relatively inelastic. In the example of a public good increase in i described in section 3.1.2, a new household moves to reside and work in i, which increases both the housing price and the wage (assuming sufficiently strong agglomeration economies). Thus, government i receives additional tax revenues and its budget deficit decreases. These effects will be opposite in sign and different in magnitude in jurisdiction j.

The *profit effect* on government j's budget deficit is:

$$\pi\text{E}^j_{\tau_i} = -m_j t^\pi_j \frac{\partial \pi_j}{\partial \tau_i}. \tag{20}$$

It is the public budget counterpart of the ownership effect on WTP (section 3.1.3). For example, an increase in the public input provision in i is likely to increase the firm's profit in i and thus reduce the budget deficit of the government if it levies a profit tax. Here we have assumed profit taxes follow the source principle, so one-hundred percent of the profit increase in jurisdiction j accrues to that jurisdiction. However, of profits are allocated according to formula apportionment (Suárez Serrato and Zidar, 2018), then this term would be scaled by the share of profits taxable in that jurisdiction according to the formula.

3.2.4. Mobility Effects

The last type of effects of a policy on a government's budget deficit are effects on revenue directly due to mobility effects. The *household mobility effect* is:

$$\text{HME}^j_{\tau_i} \equiv \frac{\partial c_j}{\partial \mathbf{n}} \frac{\partial \mathbf{n}}{\partial \tau_i} - r_j \frac{\partial n_j}{\partial \tau_i} = \sum_k \frac{\partial c_j}{\partial n_k} \frac{\partial n_k}{\partial \tau_i} - r_j \frac{\partial n_j}{\partial \tau_i} \tag{21a}$$

The household mobility effect simply states that attracting a new household to a jurisdiction might either increase or decrease the budget deficit, depending on whether the congestion cost entailed by a new resident consuming the local public services outweighs the tax revenues this new resident pays. For concreteness, consider a policy consisting in a small lump transfer in i, $\mathrm{d}s_i \equiv -\mathrm{d}t_i^n > 0$ in an economy including only two jurisdiction i and j. This transfer is likely to entail a flow of resident from j to i, i.e. $\partial n_i/\partial s_i = -\partial n_j/\partial s_i > 0$. Focusing on the effect on i's budget, expression (21a) indicates that, first, this policy increases the cost of public good provision by $(\partial c_i/\partial n_i)\partial n_i/\partial s_i > 0$ due to the new residents. However, these new residents may have been benefiting from i's public good (spillovers) when they were living in j. Subtract this opportunity cost, it follows that the net marginal congestion cost of the policy is $(\partial c_i/\partial n_i - \partial c_i/\partial n_j)\partial n_i/\partial s_i > 0$ which is likely positive because households typically consume a wider range of public services as residents than as nonresidents. Finally, each of the $\mathrm{d}n_i$ new residents pays $r_i > 0$ dollars of taxation to jurisdiction i. So the total mobility effect on jurisdiction i's budget constraint is $\text{HME}^i_{\tau_i} = (\partial c_i/\partial n_i - \partial c_i/\partial n_j - r_i)\partial n_i/\partial s_i$ which might be positive or negative depending relative levels of the taxes and congestion costs. The interpretation of the external effect $\text{HME}^{j\neq i}_{\tau_i}$ is similar.

The *firm mobility effect* on government j's public deficit is:

$$\text{FME}^j_{\tau_i} \equiv \frac{\partial c_i}{\partial \mathbf{m}}\frac{\partial \mathbf{m}}{\partial \tau_i} - t_j^\pi \pi_j \frac{\partial m_j}{\partial \tau_i} = \sum_k \frac{\partial c_j}{\partial m_k}\frac{\partial m_k}{\partial \tau_i} - t_j^\pi \pi_j \frac{\partial m_j}{\partial \tau_i} \tag{21b}$$

The interpretation is similar to that of the household mobility effect (21), except that congestion costs are now caused by firms' mobility and tax revenues are generated by the profit tax they pay.

4. The Variety of MVPFs in a Federation

This section reports the explicit formulas of the MVPF that can be calculated in a federation featuring spillovers and mobility. Section 4.1 reports the expressions of local and external MVPFs facing a given single jurisdiction. Section 4.2 defines the expressions the social MVPF facing a federal planner. Section 4.3 discusses the some economic relationships of various effects.

4.1. Local and External MVPFs

We next proceed by deriving the expressions for the local and external MVPFs for a small policy change by a single jurisdiction i. In a decentralized federation, this will result in I total MVPFs for each locality in the economy. Inserting the expressions of the marginal willingness to pay (11) and that of the marginal deficit (16) into the definition (9) of the MVPF in jurisdiction j, we obtain:

$$MVPF^j_{\tau_i} = \frac{\text{DE}^j_{\tau_i} + \text{IE}^j_{\tau_i} + \text{OE}^j_{\tau_i}}{\text{ME}^j_{\tau_i} + \text{BE}^j_{\tau_i} + \text{PE}^j_{\tau_i} + \pi\text{E}^j_{\tau_i} + \text{HME}^j_{\tau_i} + \text{FME}^j_{\tau_i}}, \tag{22}$$

$$= \frac{\text{DE}^j_{\tau_i} + (1-t^\ell_j)L_j \frac{\partial w_j}{\partial \tau_i} - (1+t^h_j)H_j \frac{\partial p_j}{\partial \tau_i} + \text{OE}^j_{\tau_i}}{\text{ME}^j_{\tau_i} - n_j \mathbf{t}_j \mathbf{q}_j \frac{\partial \mathbf{x}_j}{\partial \tau_i} - n_j \mathbf{t}_j \mathbf{x}_j \frac{\partial \mathbf{q}_j}{\partial \tau_i} - m_j t^\pi_j \frac{\partial \pi_j}{\partial \tau_i} + \left(\frac{\partial c_j}{\partial \mathbf{n}} \frac{\partial \mathbf{n}}{\partial \tau_i} - r_j \frac{\partial n_j}{\partial \tau_i}\right) + \left(\frac{\partial c_j}{\partial \mathbf{m}} \frac{\partial \mathbf{m}}{\partial \tau_i} - t^\pi_j \pi_j \frac{\partial m_j}{\partial \tau_i}\right)},$$

where the notation is as introduced earlier and summarized in the notation Table A.1. Expression (22) actually defines two different types of MVPFs depending on whether we are interested on the effect of the policy on i on itself (the local MVPF) or on another jurisdiction j (the external MVPF). Notice that for many policy instruments, the direct and mechanical effect have different forms on oneself versus external jurisdictions, and for this reason we do not substitute those terms. Given the complexity of the ownership effect, we do not make that substitution. Finally, for many of the other effects, although the functional form is the same in all jurisdictions, recall from the discussion above that the signs or magnitudes may be different depending on whether considering the local or external MVPF.

First, $MVPF^i_{\tau_i}$ is the "local" MVPF that government i would compute to assess the welfare impact of its policy from its own perspective. As government i cares only about the well being of its residents and the cost to its budget, it will not internalize any of the spillover or mobility effects on other jurisdictions. In the extreme case considered in prior literature where households and firms are immobile and wages and housing rents are constant. Then, the local MVPF (22) becomes that in Hendren (2016):[21]

$$MVPF^{\text{C}i}_{\tau_i} = \frac{\text{DE}^i_{\tau_i}}{\text{ME}^i_{\tau_i} - n_i \mathbf{t}_i \mathbf{q}_i \frac{\partial \mathbf{x}_i}{\partial \tau_i}}, \tag{23}$$

A basic comparison of (22) and (23) highlights that the open-economy MVPF has a similar form to the closed-economy MVPF derived in prior literature, but that it includes additional terms — due to mobility and spillovers and the capitalization they induce — which are likely to alter empirical MVPF estimates. In subsequent sections we discuss the potential biases of omitting these terms.

Second, $MVPF^{j \neq i}_i$ is the "external" MVPF in jurisdiction j, ignored by government i when

[21] In the particular case of the head tax discussed at length in Finkelstein and Hendren (2020), (22) becomes $MVPF^{\text{C}i}_{t^n_i} = 1/(1 + FE^i_i)$ where $FE^i_i = \mathbf{t}_i \mathbf{q}_i \partial \mathbf{x}_i / \partial t^n_i$. That is, the MVPF is one over the mechanical effect plus the behavioral effect – or one over one plus the fiscal externality.

measuring the welfare effect of its policy. In general, the external MVPF need not be zero as assumed in prior literature focusing on a single or national jurisdiction. Indeed, policies like public service provision to households and firms [profit taxation] entail direct benefits [costs] for nonresidents. Moreover, most policies conducted in one jurisdiction are likely to alter the number of residents and firms in surrounding jurisdictions. While these external spillovers might have limited use for local policymaking in i in its 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).

One attraction of the MVPF concept is that it can easily be converted from a welfare measure in monetary terms into a welfare measure in utility terms. To see this, notice that the local welfare in jurisdiction j is $n_j V_j$ because all individuals receive the same level of deterministic utility in j. Denote $MW^j_{\tau_i}$ as the local marginal welfare with respect to τ_i, that is, the effect on local welfare per dollar of policy $\mathrm{d}\tau_i$ on jurisdiction j. It can be shown that:[22]

$$MW^j_{\tau_i} = \lambda_j MVPF^j_{\tau_i} \tag{24}$$

where λ_j is the equilibrium level of the marginal utility of income in j. Importantly, λ_j is independent of the small marginal policy $\mathrm{d}\tau_i$; it only depends on the current levels of the different policy instruments. As a consequence, condition (24) indicates that in the presence of identical households, it is sufficient for government j to compare the MVPF of two different policies to be able to rank their marginal welfare impact on its residents. This result is in line with the approach in Hendren and Sprung-Keyser (2020) directly comparing the MVPF of 133 policies in various domains to assess their relative welfare impacts.[23]

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. Given decentralized policymaking, one may want to know the MVPF accounting for effects on the own jurisdiction and on other localities. Therefore, one may be interested in considering the overall effect of policy changes on the entire federal economy and then comparing this to the decentralized

[22] See Appendix A for a detailed proof.

[23] In Hendren and Sprung-Keyser (2020), they consider the U.S. as a single closed economy to which they apply a variant of the MVPF forumula (23).

planner's local MVPF. The federal planner's social welfare function is a weighted sum of utilities over all states in the federation given by $\sum_i \psi_i n_i V_i$ where ψ_i are positive social weights with unitary mean, i.e. $\sum_i \psi_i / I = 1$. The aggregate deficit of the federation is $\sum_i G_i$. We define the federal planner's MVPF, or "social" MVPF, as:[24]

$$SMVPF_{\tau_i} \equiv \frac{\sum_j WTP^j_{\tau_i}}{\sum_j G^j_{\tau_i},} \tag{25}$$

which measures how much an individual of the economy is willing to pay for each dollar spent by the by the public sector as a result of the policy. Expression (25) makes clear that if jurisdictions are symmetrically affected by the policy, the social MVPF (25) is equal to the local MVPF (22). 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 separately, just like a local planner.

Like in the local MVPF case, it is straightforward to convert the social MVPF from monetary units to social welfare units. To this aim, denote SMW_{τ_i} the social marginal welfare, that is, the effect on social welfare per dollar cost of policy $\mathrm{d}\tau_i$. It can be showed that:[22]

$$SMW_{\tau_i} = \eta_{\tau_i} SMVPF_{\tau_i} \tag{26}$$

where $\eta_{\tau_i} \equiv \sum_j \psi_j \lambda_j \sigma^j_{\tau_i}$ is the average social marginal utilities of income, $\psi_j \lambda_j$, of all the jurisdictions' representative individuals, weighted by their relative willingness to pay $\sigma^j_{\tau_i} \equiv WTP^j_{\tau_i} / \sum_k WTP^k_{\tau_i}$. Notice first that if the jurisdictions are identical and symmetrically affected by the policy, the social marginal utility of income η_{τ_i} is independent of the policy $\mathrm{d}\tau_i$ conducted (because $\sigma^j_{\tau_i} = 1/I$). Specifically, $\eta_{\tau_i} = \lambda_j$ and, as already observed, the social MVPF reduces to the local MVPF, so that condition (26) is equivalent to (24). In this case, the MVPFs of different policies can directly be compared to draw normative welfare statements.

However, in the more realistic case where the policy has heterogeneous effects on asymmetric jurisdictions, the average marginal social utility of income of two policies, say A and B, need not

[24] Following Hendren and Sprung-Keyser (2020), we define the (social) MVPF as a pure monetary measure so that its definition does not include the social weights. However, these weights become key for converting the social MVPF into social welfare units, as will be seen in equation (26) below.

be equal, i.e. $\eta_A \neq \eta_B$. In this case, to make welfare statements about these policies, the federal planner needs to compute not only the MVPF but also the marginal social utility of both policies, relying on the decision rule:

$$\eta_A SMVPF_A > \eta_B SMVPF_B \iff \text{(Policy } A \text{ is socially preferred to Policy } B\text{)}. \qquad (27)$$

Condition (27) is qualitatively similar to decision rules established in earlier literature on the MVPF (Hendren, 2016; Hendren and Sprung-Keyser, 2020). However, in our spatial equilibrium context in which jurisdictions exert spillover effects on each other, condition (27) is a stronger plea against the direct use of the MVPF as a raw tool for welfare comparisons among policies; it needs to be multiplied by the social marginal utility of the policy.[25]

Specifically, condition (27) highlights that even in an economy where all individuals and all jurisdictions are ex ante identical, any policy $d\tau_i$ conducted in jurisdiction i will have its specific average utility of income η_{τ_i} which is likely to differ from that of another policy conducted i or elsewhere. The reason is that i's policy induces policy-specific spillovers on other jurisdictions.[26]

On the contrary, assuming identical individuals and no spillover effects, Hendren and Sprung-Keyser (2020) obtain $\eta_A = \eta_B$ for any two policies A and B and can thus draw welfare conclusions from direct MVPF comparisons. Spillovers can indeed be ignored in a non-spatial economy in which policy beneficiaries are few. However, spillover effects become important to assess policies conducted by non-atomistic jurisdictions linked by economic agents' mobility and the consumption of services in nonresident jurisdictions.[27]

4.3. MVPF Measures and Price Effects

A standard practice in benefit-cost analysis, 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

[25] Section 6.4 discusses how to empirically estimate the marginal social utility of income in a multi-jurisdictional economy.

[26] Formally, spillovers imply that $WTP^i_{\tau_i} \neq WTP^{j\neq i}_{\tau_i}$ and thus $\sigma^j_{\tau_i} \neq 1/I$. It follows that for two different policies A_i and B_i, in general, we have $\sigma^j_{A_i} \neq \sigma^j_{B_i}$ because the policy have different impacts on the jurisdictions willingness to pay in the economy. It follows that $\eta_{A_i} \neq \eta_{B_i}$.

[27] Section 6.3.1 and section 6.3.2 discuss how to empirically estimate inter-jurisdictional fiscal externalities and public service spillovers.

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 due to external ownership (to the jurisdiction) of firms and housing. In our setting, then, price and wage effects will not appear in either the local WTP or the social WTP if there is local ownership of firms and the housing (land) stock, that is, all profits stay in the jurisdiction. Alternatively, if there is external ownership of profits, price and wage effects will appear in the local WTP: increases [decreases] in employee wages are not fully offset by decreases [increases] in local profits. However, again, price and wage effects do not appear in the social WTP.

Then, in the general case of some external ownership of firms and housing, price and wage effects will appear in both the local and social WTPs. 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 local and social MVPFs.

A related concern that arises in benefit-cost analysis is of "double counting." The following is an example of this from a 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 local WTP, 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 local WTP is zero. However, if the farmer is renting land owned by an absentee landowner living outside the jurisdiction, then the local WTP includes both the farmer's income stream and the cost of an increase in rent to him. As local WTP 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 external WTP. As discussed, the price effects will cancel in the social WTP.

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 using the structure of our spatial general equilibrium model. Section 5.1 considers the case of "small" jurisdictions. Section 5.2 describes the MVPFs of household policies in a general two-jurisdiction model focusing on household inter-jurisdictional mobility. Section 5.3 describes the MVPFs of business policies in a two-jurisdiction economy with firm mobility.

5.1. MVPF with Atomistic Jurisdictions

Much of the literature in state and local public economics assumes atomistic jurisdictions, e.g., the original form of the Zodrow and Mieszkowski (1986)-Wilson (1986) model, 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 $WTP^i_{\tau_i}$ is equal to zero. However, the indirect effects on asset prices, for example, housing prices affect the incomes and, therefore, utility of those owning these assets.

However, for a policy change in i, while the external effect on an individual jurisdiction, $WTP^j_{\tau_i}$, approaches zero as the size of the jurisdiction i approaches zero, the sum of $WTP^j_{\tau_i}$ do not and, therefore, neither does the social WTP. To see this, consider a simple example of I 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 $\partial p_i/\partial g_i = (1 - 1/I)\,\text{DE}^i_{g_i}$ and decreases rent in each of the other $I-1$ jurisdictions by $\partial p_j/\partial g_i = -\frac{1}{I}\text{DE}^i_{g_i}$, $j \neq i$, where $\text{DE}^i_{g_i}$ is the direct benefit from the increase in g_i. Then as the number of jurisdictions becomes large ($I \to \infty$) the direct effect of the increase in g_i on utility is entirely offset by effect of the price increase in any one jurisdiction j. However, while in the limit, $WTP^j_{\tau_i}$ approaches zero for one jurisdiction ($\lim_{I\to\infty} WTP^j_{\tau_i} = -\partial p_j/\partial g_i = 0$, $j \neq i$) the sum of the external willingness to pay $\sum_{j\neq i} WTP^j_{\tau_i} = (I-1)\partial p_j/\partial g_i$, 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 $WTP^i_{g_i} = \text{DE}^i_{g_i}$ and $\sum_{j\neq i} WTP^j_{\tau_i}$ with $SWTP$ remaining equal to $\text{DE}^i_{g_i}$.

5.2. Household Policies in a Two-Jurisdiction Model

The purpose of this section is to compare the local, social and closed-economy MVPFs of household-oriented public policy instruments. To do this, we need to characterize how the economy responds to changes in the level of the policy instruments of a given jurisdiction. In the fully flexible model introduced in section 2, these responses are by nature ambiguous and depend on model specifications (e.g. different utility, housing supply, and production functions) and the calibration of the model. To gain intuition, only this subsection focuses on a special case that guarantees meaningful economic responses that are intuitive.

The rest of this section is organized as follows. Section 5.2.1 lists the simplifying assumptions made in this section. Section 5.2.2 derives the responses of the economy to policy changes. Section 5.2.3 compares the open-economy and closed-economy MVPFs. Section 5.2.4 compares the local and social MVPFs.

5.2.1. Assumptions and MVPFs

We consider an economy with two jurisdictions indexed by $i = 1, 2$. As the focus on this subsection is on household-oriented instruments $P_i = \{t_i^x, t_i^\ell, t_i^h, g_i\}$, we ignore business-oriented policy instruments: profit taxation and business public services ($t_i^\pi = z_i = 0$). The public cost function reduces to a function of the local public good provision g_i and the local population n_i, $c_i = c_i(g_i, n_i)$.[28] The individual firm's production function is $f_i = f_i(l_i, L_i)$. To further focus on households, we assume that firms are immobile across jurisdictions, so that the number of firms in each jurisdiction, m_i, is fixed. Moreover, housing and firm profits are assumed to accrue to absentee owners. The individuals' labor supply and housing demand are assumed inelastic and equal to one, so that rent and wage variations only result from population changes. The utility function (1) is $U_i + e_i = U(x_i, g_i, g_{-i}) + e_i$ and the budget constraint is $y_i + (1 - t_i^\ell)w_i = (1 + t_i^x)x_i + (1 + t_i^h)p_i + t_i^n$.

The idiosyncratic preference of individuals for a jurisdiction, 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 Euler's constant and μ is a positive constant which is inversely proportional to the variance of e_i.[29] Then, the num-

[28] We write the public cost function with only two arguments, $c_i = c_i(g_i, n_i)$, instead of using three arguments, $c_i = c_i(g_i, n_i, n_{-i})$, as in the previous sections. In a two-jurisdiction model, this is without loss of generality as the population of jurisdiction $-i$ can be expressed as a bijective function of the population of jurisdiction i using the population clearing $n_i + n_{-i} = N$, so that $c_i = c_i(g_i, n_i, n_{-i}) = c_i(g_i, n_i, N - n_i) \equiv \tilde{c}_i(g_i, n_i)$.

[29] This modeling of household mobility is in line with Kline and Moretti (2014), Suárez Serrato and Zidar (2016) and many others. Alternatively, assuming that e_i enters the utility in multiplicative form and follows a Fréchet distribution as in Ahlfeldt et al. (2015) would not alter our results. Roughly speaking, the exponential is simply

ber of households choosing to live in jurisdiction i yields the population equilibrium condition $n_i = N \exp(\mu V_i)/\sum_j \exp(\mu V_j)$. Parameter μ measures the degree of inter-jurisdictional mobility. If μ goes to zero, the expression for n_i indicates that households are immobile and all jurisdictions have the same population. If μ goes to infinity, then the variance of the idiosyncratic parameter, e_i, goes to zero; all households are identical, mobility is costless and utility is equated across jurisdictions (Roback, 1982).

Under these assumptions, the MVPF in jurisdiction j of a policy $\mathrm{d}\tau_i$ consisting of a change by jurisdiction i in one of its policy instruments $\tau_i \in P_i$ is:

$$MVPF^j_{\tau_i} = \frac{\text{DE}^j_{\tau_i} + \text{IE}^j_{\tau_i}}{\text{ME}^j_{\tau_i} + \text{BE}^j_{\tau_i} + \text{PE}^j_{\tau_i} + \text{HME}^j_{\tau_i}}, \tag{28}$$

where we can observe that, compared to the general formula (22), the ownership, profit and firm-mobility effects are absent because we assumed external ownership, no profit tax and immobile firms. The direct and mechanical effects are as defined in (12) and (17):

$$\text{DE}^i_{t^b_i} = \text{ME}^i_{t^b_i} = -n_i \text{B}^b_i, \qquad \text{DE}^j_{g_i} = \frac{n_j}{\lambda_j}\frac{\partial U_j}{\partial g_i}, \qquad \text{ME}^i_{g_i} = \frac{\partial c_i}{\partial g_i}, \qquad \text{DE}^{j \neq i}_{t^b_i} = \text{ME}^{j \neq i}_{\tau_i} = 0, \tag{29a}$$

where $b = \ell, h, x, n$ but the per capita tax bases are now simply $\text{B}^\ell_i = w_i$, $\text{B}^h_i = p_i$, $\text{B}^x_i = x_i$ and $\text{B}^n_i = 1$. The disposable income effect becomes:

$$\text{IE}^j_{\tau_i} = n_j \left((1 - t^\ell_j)\frac{\partial w_j}{\partial \tau_i} - (1 + t^h_j)\frac{\partial p_j}{\partial \tau_i} \right), \tag{29b}$$

and the behavioral, price and household-mobility effects become respectively:

$$\text{BE}^j_{\tau_i} = -n_j t^x_j \frac{\partial x_j}{\partial \tau_i}, \qquad \text{PE}^j_{\tau_i} = -n_j \left(t^\ell_j \frac{\partial w_j}{\partial \tau_i} + t^h_j \frac{\partial p_j}{\partial \tau_i} \right), \qquad \text{HME}^j_{\tau_i} = \left(\frac{\partial c_j}{\partial n_i} - r_j \right) \frac{\partial n_j}{\partial \tau_i}. \tag{29c}$$

The social MVPF (25) is simply the ratio of the sum of the numerator of (28) to the sum of its denominator over all the jurisdictions j in the economy. Moreover, expression (28) also allows us to easily obtain the expressions of the expression of the closed-economy MVPF which assumes immobile households. Further, under the assumptions described above, housing price and wage changes only result from household mobility. Assuming that households are immobile across jurisdictions implies

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.

that housing rents and wages are constant. This implies that the expression of the closed-economy MVPF, $MVPF^{ci}_{\tau_i}$, is obtained by simply suppressing the mobility effect $\text{HME}^{i}_{\tau_i}$ and the price effect $\text{PE}^{i}_{\tau_i}$ from the expression of $MVPF^{i}_{\tau_i}$ (28).

Next, we sign and provide intuition into the different effects in (28), in order to compare the levels of the closed-economy, open-economy, and social MVPFs.

5.2.2. Responses of the Economy to Policy Changes

To compare MVPFs, we derive general equilibrium comparative statics result which allow us to sign all the terms in the MVPF expressions (28). These comparative statics, while not necessary to derive any of the formulas 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.

Differentiating the migration equilibrium condition with respect each tax t_i^b, $b = \ell, h, x, n$ and with respect to spending policy g_i, we obtain:[30]

$$\frac{\partial n_i}{\partial t_i^b} < 0, \qquad \qquad \frac{\partial n_i}{\partial g_i} > 0. \tag{30}$$

which, as expected, states that an increase in local taxation entails outflows of residents, while an increase in public good provision attracts new residents.

The population responses to a policy allow us to derive the housing rent and wage responses. In the current simplified framework, Appendix B shows that both are uniquely direct functions of the local population, $p_i(n_i)$ and $w_i(n_i)$. Moreover, the appendix shows that any population increase entails positive rent capitalization, i.e. $\partial p_i/\partial n_i > 0$. However, the sign of wage capitalization is ambiguous. Specifically, we show that $\partial w_i/\partial n_i = \alpha_i - \beta_i$ where $\alpha_i > 0$ measures the degree of agglomeration economies and $\beta_i > 0$ measures the strength of decreasing marginal returns to labor. In the absence of agglomeration economies ($\alpha_i = 0$), the wage is a decreasing function of the population because each additional worker is less productive than the previous one. However, if agglomeration economies are large enough ($\alpha_i > \beta_i$), the wage increases with respect to the population.[31] The signs of the housing rent and wage responses directly follow from (30), $\partial p_i/\partial n_i >$

[30] The detailed derivations of the sign conditions in this section can be found in Appendix B. All the sign conditions are summarized in Table A.2.

[31] Rosenthal and Strange (2008a), Ciccone and Hall (1996), and Ahlfeldt et al. (2015) document the existence of strong agglomeration economies, especially at the local level.

0 and $\text{sign}(\partial w_i/\partial n_i) = \text{sign}(\psi_i)$. They are:

$$\frac{\partial p_i}{\partial t_i^b} < 0, \qquad \frac{\partial p_i}{\partial g_i} > 0, \qquad \text{sign}\left(\frac{\partial w_i}{\partial t_i^b}\right) = -\text{sign}\left(\frac{\partial w_i}{\partial g_i}\right) = -\text{sign}(\alpha_i - \beta_i), \tag{31}$$

We know from (30) that a marginal increase in any tax entails outflows of residents. Condition (31) 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 [weak] agglomeration economies $\alpha_i > [<]\beta_i$, less population also means a lower [higher] wage. Condition (31) also states that the opposite responses occur when the local public good provision is increased, because public goods allow to attract new residents.

Next, we turn to the responses of private consumption x_i to policy changes. Differentiating the budget constraint $x_i = \left(y_i + (1 - t_i^\ell)w_i - (1 + t_i^h)p_i - t_i^n\right)/(1 + t_i^x)$, it can be shown that:

$$\frac{\partial x_i}{\partial t_i^b} < 0, \qquad \text{sign}\left(\frac{\partial x_i}{\partial g_i}\right) = \text{sign}\left(\text{IE}^i_{n_i}\right). \tag{32}$$

where $\text{IE}^i_{n_i} \equiv (1 - t_i^\ell)\text{d}w_i/\text{d}n_i - (1 + t_i^h)\partial p_i/\partial n_i$ is the disposable income effect entailed by an inflow of residents. The first condition in (32) indicates that the direct negative income effect of taxation implies that an increase in local taxation always spurs the residents to reduce their consumption. The second condition in (32) states that if public good provision increases, local consumption increases only if the inflow of new residents attracted by the extra public goods induces an increase in the local disposable income. Otherwise, local consumption decreases. In the case of strong agglomeration economies ($\alpha_i \gg \beta_i$), household inflows capitalize more into the wage than into housing rents, so that local disposable income and the local consumption increase. On the contrary, if the local wage decreases ($\alpha_i < \beta_i$) or increases more slowly than the housing rent ($\alpha_i \approx \beta_i$), following the entry of new residents, consumption decreases.

Similarly, we obtain the external effects on jurisdiction $j \neq i$ of each policy instrument of i:

$$\text{sign}\left(\frac{\partial x_j}{\partial t_i^b}\right) = -\text{sign}\left(\frac{\partial x_j}{\partial g_i}\right) = \text{sign}\left(\text{IE}^j_{n_j}\right). \tag{33}$$

Condition (33) indicates that an 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 it varies in the same direction as the disposable income. Again, the effect of public good provision goes in the opposite direction.

The properties (30)–(33) allow us to sign all the components of the MVPFs (28), as reported in Table A.2. However, comparison of the local, closed-economy and social MVPFs requires a bit more. It requires us to identify states of the economy in which the spillover effects induced by household mobility ($\text{IE}^j_{\tau_i}$, $\text{PE}^j_{\tau_i}$ and $\text{HME}^j_{\tau_i}$) unambiguously improve or deter both the marginal willingness to pay and the net government revenue. We identify two such states of the economy, which allow to unambiguously compare the MVPFs. The first of these is characterized by the following assumption:

Assumption 1 (strong agglomeration forces). *The economy is characterized by significant private and public agglomeration forces, so that for each $i = 1, 2$:*[32]

$$(1 - t_i^\ell)\frac{\partial w_i}{\partial n_i} > (1 + t_i^h)\frac{\partial p_i}{\partial n_i} > 0 \qquad \text{(34a)} \qquad\qquad r_i > \frac{\partial c_i}{\partial n_i} \qquad \text{(34b)}$$

This assumption implies that attracting a new resident improves the residents' welfare and the government's net revenues. Condition (56) implies that the positive effect on wages and rents induced by a marginal resident, increase disposable income (despite the rent increase) and the property and labor tax revenues. Public agglomeration economies, condition (34b), means that a marginal resident pays taxes exceeding the congestion cost she induces.

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

Assumption 2 (strong dispersion forces). *The economy is characterized by significant private and public dispersion forces, so that for each $i = 1, 2$:*[33]

$$t_i^\ell \frac{\partial w_i}{\partial n_i} < -t_i^h \frac{\partial p_i}{\partial n_i} < 0 \qquad \text{(35a)} \qquad\qquad r_i < \frac{\partial c_i}{\partial n_i} \qquad \text{(35b)}$$

This implies that a new resident lowers the residents' welfare and the government's net revenues. Condition (56) implies that the wage increase and rent decrease induced by a new resident reduce disposable income and property and labor tax revenues. For public production, condition (34b), means that a marginal resident induces a congestion costs exceeding the taxes she pays.

[32] As $\partial p_i/\partial n_i$ is always positive, the notable assumption in (56) is the left-hand side of the 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 requires strong agglomeration economies, i.e. $\alpha_i \gg \beta_i$.

[33] The first inequality in (35a) imposes the wage decreases sufficiently fast compared to the housing rent increases as a response to a population increase. This requires sufficiently strong decreasing marginal product of labor, i.e. $\alpha_i \ll \beta_i$.

Assuming either Assumption 1 or Assumption 2 is sufficient for establishing unambiguous comparisons of the local, closed and social MVPFs.

5.2.3. 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? Suppose that a researcher interested in the local MVPF of a policy is able to estimate all the responses in the MVPF formulas (28), but she assumes that households are immobile, thus using the formula for $MVPF^{ci}_{\tau_i}$. In which direction are these "wrong" closed economy estimates of the MVPFs biased compared to the "true" open economy estimates accounting for household mobility?

Let us first assume that Assumption 1 holds, so that agglomeration forces in the economy are strong. Consider a small increase in one of the tax instrument t^b_i, $b = \ell, h, x, n$. The open-economy (local) $MVPF^i_{t^b_i}$ and the closed-economy $MVPF^{ci}_{t^b_i}$ can be unambiguously ranked as follows:[34]

$$MVPF^i_{t^b_i} = \frac{\mathrm{DE}^i_{t^b_i} + \overbrace{\mathrm{IE}^i_{t^b_i}}^{<0}}{\mathrm{ME}^i_{t^b_i} + \mathrm{BE}^i_{t^b_i} + \underbrace{\mathrm{PE}^i_{t^b_i} + \mathrm{HME}^i_{t^b_i}}_{>0}} < \frac{\mathrm{DE}^i_{t^b_i}}{\mathrm{ME}^i_{t^b_i} + \mathrm{BE}^i_{t^b_i}} = MVPF^{ci}_{t^b_i}, \tag{36}$$

where the signs are collected from the summary Table A.2. Condition (36) indicates that, in the presence of strong agglomeration economies, if the researcher assumes that households are immobile, this leads to overestimating the MVPF. The numerators in (36) indicate 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 disposable income. The denominators in (36) also highlights a missing budgetary cost when using $MVPF^{ci}_{t^b_i}$ instead of $MVPF^i_{t^b_i}$. Indeed, the reduction in population reduces not net tax revenues directly, but also indirectly due to the resulting wage and housing price decreases, which reduce the property and income tax revenues.

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 — or larger than — other behavioral

[34] The MVPF comparisons in this section are summarized in Table A.3

responses, such as changes to labor supply (Saez et al., 2012).[35] Moreover, the capitalization effects of taxation are also important (Feldstein and Wrobel 1998, Löffler and Siegloch 2021).

Next, consider a small increase in public good provision g_i, in the presence of strong agglomeration economies. 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 comparing $MVPF^{ci}_{g_i^b}$ (no mobility) to $MVPF^{i}_{g_i^b}$ (with mobility) leads to overestimating the MVPF. Reversing the signs in (36), we obtain $MVPF^{i}_{g_i} > MVPF^{ci}_{g_i}$. 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 there are more households with higher wages and rents that also indirectly increase property and labor tax revenues.

Again, the magnitudes of these biases 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; Epple et al. 2001). 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, 2008b), so the validity of the assumption used to derive the bias may depend on the precise nature of the program.

Let us now assume that Assumption 2 holds, so that dispersion forces in the economy are strong. Consider a small increase in one of the tax instrument t_i^b. Because the disposable income effect, the price effect and the household mobility effect are now positive (Table A.2), the signs in (36) are reversed and $MVPF^{i}_{t_i^b} > MVPF^{ci}_{t_i^b}$. 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. The closed-economy MVPF also ignores the fact that mobility reduce the public deficit because fewer residents mean (i) lower costs of public good provision, and (ii) an increase in the wage, which increases labor tax revenues offsetting the cut in property tax revenues due to the reduction in the housing rent.

[35] 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 of mobility. This is simply acheived by converting our destination-based consumption tax to an origin-based tax. 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.

Again, as public goods attract new residents contrary to taxation which repels them, we can directly infer that $MVPF^{i}_{g_i} < MVPF^{ci}_{g_i}$. The interpretation is the symmetric opposite to that for taxes. The results in this subsection are summarized in the following proposition:

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

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

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

5.2.4. Local MVPF versus Social MVPF

Assessing the welfare effect of a policy in a federation raises a fundamental issue that many policies are decided by local or regional governments, accounting for the welfare of their own residents only, although their policies affect other jurisdictions (Oates, 1972; Wildasin, 1989). Only the federal government can reasonably internalizes these spillovers for the social impact of a local policy. This conflict between local and social objective allows us to use the MVPF to assess decentralized versus centralized decision-making.

Consider for example, a policy enacted by jurisdiction i, which induces important wage increases in other jurisdictions so that non-residents are willing to pay for the policy and the deficit of other governments' would be reduced due to extra labor tax revenues. The MVPF of this policy as calculated by government i would not account for these spillover benefits and could therefore be significantly lower than the social MVPF. By underestimating the social benefit of a policy, a local government might well decide not to implement a "good" policy and favor some other "bad" policies inducing larger own-jurisdiction benefits, but coming with social losses to nearby jurisdictions. The purpose of this subsection is to investigate these possible divergences between local and social MVPFs. We exploit our two-jurisdiction model to identify the policy instruments and the state of the economy which might lead a local MVPF to overestimate or underestimate the social MVPF.

Let us first assume that Assumption 1 holds, so that agglomeration forces in the economy are strong. Consider a small increase in one of the tax instrument t^b_i, $b = \ell, h, x, n$. The local $MVPF^{i}_{t^b_i}$

and the social $SMVPF_{t_i^b}$ can be unambiguously ranked as follows:[36]

$$MVPF_{t_i^b}^i = \frac{\text{DE}_{t_i^b} + \text{IE}_{t_i^b}^i}{\text{ME}_{t_i^b} + \text{BE}_{t_i^b}^i + \text{PE}_{t_i^b}^i + \text{HME}_{t_i^b}^i}$$
$$< \frac{(\text{DE}_{t_i^b} + \text{IE}_{t_i^b}^i) + \overbrace{(\text{DE}_{t_i^b}^{j\neq i} + \text{IE}_{t_i^b}^{j\neq i})}^{>0}}{(\text{ME}_{t_i^b} + \text{BE}_{t_i^b}^i + \text{PE}_{t_i^b}^i + \text{HME}_{t_i^b}^i) + \underbrace{(\text{BE}_{t_i^b}^{j\neq i} + \text{PE}_{t_i^b}^{j\neq i} + \text{HME}_{t_i^b}^{j\neq i})}_{<0}} = SMVPF_{t_i^b}, \qquad (37)$$

where the signs are collected from the summary Table A.2. Notice that $\text{DE}_{t_i^b}^{j\neq i} = 0$ because none of the taxes considered entail an external direct effect.Condition (37) indicates that in the presence of strong agglomeration forces, for any tax instrument, the social MVPF is larger than the local MVPF. Specifically, the numerator of the social MVPF indicates that the non-residents would be ready to pay for i to increase its tax t_i^b, because a higher tax in i entails relocation of residents-workers to jurisdiction j where the wage increases faster than rents due to agglomeration, and thus increases disposable income. The denominators in (37) indicate that the local MVPF ignores the reduction in the public deficit in j due to i increasing its tax — an interjurisdictional fiscal externality. Indeed, the inflow of new residents in j entails three positive budgetary effects in j: (i) it increases the per capita tax revenues net of congestion costs; (ii) it increases the rent and wage and thus the property and labor tax revenues; and (iii) by increasing disposable income, it increases the numéraire consumption and, thus, commodity tax revenues.

Consider a small increase in public good provision g_i, in the presence of strong agglomeration economies. Compared to taxation, the main difference is that public goods entail positive external direct effect, $\text{DE}_{g_i}^{j\neq i} > 0$, due to spillovers. If these spillover effects are sufficiently high, the local MVPF underestimate the social MVPF. If they are relatively low, given that, as already noticed before, the qualitative effect of public good provision on mobility is simply the opposite of that of taxation, the sign of the effects represented in (37) are simply reversed, and we have $MVPF_{g_i}^i > SMVPF_{g_i}$, that is, the local MVPF overestimates the social MVPF. Thus, even with assumption of agglomeration economies, ranking the social and local MVPF for public services requires information on the spillover benefits of the services.

Let us now assume that Assumption 2 holds, so that dispersion forces in the economy are

[36] The MVPF comparisons in this section are summarized in Table A.3

strong. Again, all the signs stated for the strong-agglomeration case in condition (37) are reversed and we have $MVPF^i_{t^b_i} > SMVPF_{t^b_i}$, that is, the local MVPF overestimates the social MVPF. The reason is that the local MVPF ignores negative welfare and budget spillovers exerted on other jurisdictions by increasing the number of residents elsewhere. This population growth strongly reduces the wage in these jurisdictions, which entails a reduction in disposable income and less labor and commodity tax revenues. If spillover benefits to other jurisdiction are small, then it follows that $MVPF^i_{g_i} < SMVPF_{g_i}$: the local MVPF underestimates the social MVPF, because it does not account for the benefits of reducing the population of other jurisdictions when dispersion forces are strong. The results in this subsection are summarized in the following proposition:

Proposition 2. *Consider a two-jurisdiction economy with immobile firms, in which the individual housing demand and labor supply are inelastic. Assuming moderate public good spillovers, the following results hold:*

(i) If agglomeration forces are relatively high then, for tax [public good provision] changes, the local MVPF is underestimates [overestimates] the social MVPF.

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

If, however, public good spillovers are relatively high, we have:

(iii) Whatever the levels of agglomeration and dispersion forces, for public good provision changes, the local MVPF is underestimates the social MVPF.

5.3. Business Policies in a Two-Jurisdiction Model

In this section, we are interested in the policy responses and the MVPFs with respect to a small increase in the business public service z_i or in the profit tax t^π_i of jurisdiction i. A common theme in the local tax competition literature is that jurisdictions "bid" for firms by offering subsidy deals that consist of either business-tax breaks or the provision of added business public services by the locality. Section 5.3.1 reports the assumptions made to focus on the interplay between business policies and firm mobility and states the resulting MVPF formulas. Section 5.3.2 describes how the economic variables respond to policy changes. Section 5.3.3 compares the local and social MVPFs. Appendix C derives all the results reported in this section.

5.3.1. Assumptions and MVPFs

In order to focus on business policies, we make the following simplifications, which parallel our household example described in section 5.2 but invoking several polar opposite assumptions. Consider a two-jurisdiction economy in which each household is now immobile and consumes a single unit of housing and supplies a single unit of labor. As households are immobile and we do not consider changes in public good provision, we can assume, without loss of generality, that no public good provided to households. Also, it is not necessary to model housing because the inelasticity of individual housing demand and household immobility imply that each jurisdiction's housing stock and housing rent are exogenous. The utility of a resident of i is $U_i(x_i)$ and her budget constraint is $(1 + t_i^x)x_i = (1 - t_i^\ell)w_i + y_i$. Assume that firms are owned by a large number of households across all states in the federation so that residents of any one state owns a negligible profit share, i.e. $\forall i, j$, $\theta_i^j = 0$, so that the non-labor income is exogenous.

The firm chooses its labor supply l_i so as to maximize its net profit $(1 - t_i^\pi)\pi_i \equiv (1 - t_i^\pi)[f_i(l_i, z_i, z_j) - w_i l_i]$. Firms are assumed to be perfectly mobile across jurisdictions, which implies that net profits are equated across jurisdictions. As will become clear, not all firms will move to a given jurisdiction because entry raises wages and lowers profits. For simplicity, we ignore agglomeration economies. The resource constraint of the number of firms is $m_1 + m_2 = M$ and the clearing condition of the labor market is $n_i = m_i l_i$. The general equilibrium of the model defines, in each jurisdiction $i = 1, 2$, the number of firms m_i, the wage w_i and the profit π as a function of the profit tax and the public input in 1, i.e. t_1^π and z_1.

Given these assumptions, the expression of the MVPF in jurisdiction j of a policy change implemented in jurisdiction i is, for each policy instrument $\tau_i \in \{t_i^\pi, z_i\}$:

$$MVPF_{\tau_i}^j = \frac{\text{IE}_{\tau_i}^j}{\text{ME}_{\tau_i}^j + \text{BE}_{\tau_i}^j + \text{PE}_{\tau_i}^j + \pi\text{E}_{\tau_i}^j + \text{FME}_{\tau_i}^j} \tag{38}$$

where we can observe that several effects are absent compared to (22). First, as established in the general MVPF formula the direct effect on willingness to pay of public inputs is always zero. Here, the direct effect of a profit tax is also zero because individuals' profit shares are negligible. Second, the ownership effect on the willingness to pay is zero for the same reason. Last, the household mobility effect on the net cost to government is missing because households are assumed to be immobile. The direct and mechanical effects are as defined in (12) and (17):

$$\text{ME}^i_{t^\pi_i} = -m_i \pi_i, \qquad \text{ME}^i_{z_i} = \frac{\partial c_i}{\partial z_i}, \qquad \text{ME}^{j\neq i}_{\tau_i} = 0, \tag{39}$$

The disposable income effect becomes:

$$\text{IE}^j_{\tau_i} = n_j (1 - t^\ell_j) \frac{\partial w_j}{\partial \tau_i}, \tag{40}$$

recalling that housing rents are exogenous in the present case. The behavioral effect, the price effect, the profit effect and the mobility effect are:

$$\text{BE}^j_{\tau_i} = -n_j t^x_j \frac{\partial x_j}{\partial \tau_i}, \quad \text{PE}^j_{\tau_i} = -n_j t^\ell_j \frac{\partial w_j}{\partial \tau_i}, \quad \pi\text{E}^j_{\tau_i} = -m_j t^\pi_j \frac{\partial \pi_j}{\partial \tau_i}, \quad \text{FME}^j_{\tau_i} = \left(\frac{\partial c_j}{\partial m_j} - t^\pi_j \pi_j \right) \frac{\partial m_j}{\partial \tau_i}, \tag{41}$$

Notice that although congestion effects due to firm mobility are probably non-zero in practice, it is likely that attracting an additional firm allow a jurisdiction to increase its tax revenues net of congestion costs. Thus, we assume in the following subsections that $t^\pi_j \pi_j > \partial c_j / \partial m_j$.

5.3.2. *Responses of the Economy to Policy Changes*

The general equilibrium local number of firms m_i, wage w_i and profit π_i respond to profit taxation as follows, for $i = 1, 2$ and $j \neq i$:

$$\frac{\partial m_i}{\partial t^\pi_i} < 0, \qquad \frac{\partial w_i}{\partial t^\pi_i} < 0, \qquad \frac{\partial x_i}{\partial t^\pi_i} < 0, \qquad \frac{\partial \pi_i}{\partial t^\pi_i} > 0, \tag{42}$$

and $\text{sign}(\partial \text{X}_j / \partial t^\pi_i) = -\text{sign}(\partial \text{X}_i / \partial t^\pi_i)$ for $j \neq i$ and $\text{X} = m, w, \pi$. Condition (42) indicates that an increase in the profit tax entails outflows of firms from jurisdiction i, which exerts an upward pressure on the local wage and thus reduces the local profit of a firm, but allows the residents to consume more. On the opposite, profit taxation in i makes j more attractive to firms and thus increases the wage and reduces the profit in j. The responses with respect to changes in public input provision are, for $i = 1, 2$, $k = 1, 2$ and $j \neq i$:[37]

$$\frac{\partial m_i}{\partial z_i} > 0, \qquad \frac{\partial m_j}{\partial z_i} < 0, \qquad \frac{\partial w_k}{\partial z_i} > 0, \qquad \frac{\partial x_k}{\partial z_i} > 0, \qquad \frac{\partial \pi_k}{\partial z_i} > 0, \tag{43}$$

[37] Notice that $\partial w_j / \partial z_i > 0$ implicitly assumes that spillover effects are relatively strong. Table A.4 reports how the results derived in this section are altered by assuming that spillover effects are weak.

that is, public input provision in i allows jurisdiction i to attract new firms. The wage in i increases both due to the direct positive effect of public inputs on firms productivity and due to the attraction of new firms in the jurisdiction. Despite the increase in the wage, the profit in i increases due to the direct effect of public inputs on firms' productivity. The responses in jurisdiction j indicate that j's wage increases as a result of public input provision in i, assuming that spillover effects are strong enough. Moreover, the profit in j increases for two reasons: (1) public inputs directly increase profit because of production gains and (2) the firm outflight reduces local business competition. Table A.4 summarizes the signs of the responses to policy changes derived in (42) and (43), and reports the implications for the components of the MVPFs.

5.3.3. Local MVPF versus Social MVPF

The responses described in section 5.3.2 allow to sign all the component of the MVPFs as reported in Table A.4 and interpreted in appendix C.3. Furthermore, these responses allow to compare the levels of the local and social MVPFs of business policy instruments. The present subsection establishes and interpret the ranking of these two types MVPFs. Let us first consider an increase in the profit tax t_i^π. The signs of the components of the external MVPF, reported in columns 2 Table A.4, allow us to state:

$$SMVPF_{t_i^\pi} = \frac{WTP^i_{t_i^\pi} + \overbrace{\mathrm{IE}^{j\neq i}_{t_i^\pi}}^{>0}}{G^i_{t_i^\pi} + \underbrace{\mathrm{BE}^{j\neq i}_{t_i^\pi}}_{<0} + \underbrace{\underbrace{\mathrm{PE}^{j\neq i}_{t_i^\pi}}_{<0} + \underbrace{\pi\mathrm{E}^{j\neq i}_{t_i^\pi}}_{>0}}_{<0} + \underbrace{\mathrm{FME}^{j\neq i}_{t_i^\pi}}_{<0}} > MVPF^i_{t_i^\pi} \tag{44}$$

where $WTP^i_{t_i^\pi}$ and $G^i_{t_i^\pi}$ are the numerator and denominator in (38), respectively. Notice first, that the price effect is assumed to dominate the profit effect. In the United States, it is likely the case for two reasons. First, profit tax rates are generally lower than income tax rates, and business taxes generate much less revenue for state governments than labor-based taxes. Moreover, as profits are usually taxed according formula apportionment that generally overweight sales, even though production occurs in the jurisdiction, profit taxes may not be sourced to that jurisdiction. Thus, the profit effect – which in our theoretical model is based on the source principle – requires adjustment by the share of profits allocated to the jurisdiction under formula apportionment.

Condition (44) reveals an important result: a local government is likely to underestimate [overestimate] the social MVPF of a profit tax increase [cut] when computing its local MVPF. That is, by increasing its profit tax, jurisdiction i spurs firms to relocate to jurisdiction j which therefore benefits from gains that are not accounted for by jurisdiction i. Specifically, the numerator of (44) indicates that j's residents are willing to pay for i's to increase its profit tax. Doing so, i would induce an inflow of firms in j and thus an increase in wage received by j's residents.

The denominator of (44) indicates that the local MVPF computed by jurisdiction i ignores three types of benefits to jurisdiction j which reduce the aggregate net budgetary cost of the policy. First, more firms generate more tax revenues due to a scale effect ($\text{FME}_{t_i^\pi}^{j\neq i} < 0$). Second, the additional firms in j increase the competition for workers, which increases the local wage and thus tax revenues from labor taxation ($\text{PE}_{t_i^\pi}^{j\neq i} < 0$). Third, the wage increase allow j's resident to consume more and thus pay more commodity tax ($\text{BE}_{t_i^\pi}^{j\neq i} < 0$).[38]

Let us now turn to the MVPFs of public input provision. The signs of the components of the external MVPF, reported in columns 5 Table A.4, allow us to state:[39]

$$SMVPF_{z_i} = \frac{WTP^i_{z_i} + \overbrace{\text{IE}^{j\neq i}_{z_i}}^{>0}}{G^i_{z_i} + \underbrace{\text{BE}^{j\neq i}_{z_i}}_{<0} + \underbrace{\underbrace{\text{PE}^{j\neq i}_{z_i}}_{<0} + \underbrace{\text{FME}^{j\neq i}_{z_i}}_{>0}}_{<0} + \underbrace{\pi\text{E}^{j\neq i}_{z_i}}_{<0}} > MVPF^i_{z_i}, \tag{45}$$

where the price effect is assumed to dominate the mobility effect based on the same argument previously. Assuming sufficiently large public services spillovers, condition (45) indicates that, like in the case of the profit tax, the MVPF of public input provision assessed by a local government underestimates the social MVPF. The overall intuition is straightforward: public services provided in i benefit to j due to spillovers, but i does not account for these external gains (Wildasin, 1989). Specifically, the numerator of (45) shows that the local willingness to pay ignores that public inputs increase both the wage and thus the disposable income received by the residents of j, due to spillovers. It follows that non-residents enjoy an increase in both their labor income and their profit income.

The denominator of (45) indicates that jurisdiction i's local MVPF also ignores tax revenue

[38] Again, the wage increase reduces the profit in j and thus the profit tax revenues it collect but, as already discussed, this negative budgetray effect is likely dominated by the positive budgetary effects described above.

[39] As mentioned earlier, we that the magnitude of public service spillovers is large enough for $\partial w_j/\partial z_i$ to be positive (see e.g. footnote 37). Besides, (45) assumes that the mobility effect $\text{FME}^{j\neq i}_{z_i}$ is dominated by the price effect $\text{PE}^{j\neq i}_{z_i}$ because, in practice, the income tax bases and revenues are significantly more important than the business tax bases and revenues, as already discussed.

benefits to government j. First, higher wages in j allow j to collect more labor tax revenues ($\text{PE}_{z_i}^{j\neq i} < 0$). Second, higher wages in j spur j's residents to consume more and thus pay more commodity taxes ($\text{BE}_{z_i}^{j\neq i} < 0$). Finally, due to spillovers, the profit increases in j which entails more profit tax revenues ($\pi\text{E}_{z_i}^{j\neq i} < 0$). The main results sated in this section are summarized in:

Proposition 3. *Suppose that business service spillovers are relatively large. For an increase in the profit tax or in public business services, the local MVPF understates the social MVPF.*

Proposition 3 highlights an asymmetric outcome of two types of business incentives (tax reduction and public service provision) in an open economy with important public service spillover effects. When cutting its business tax rate, a jurisdiction essentially ignores the cost imposed on other jurisdictions which lose firms: the social MVPF is overstated by the local MVPF. However, when providing public services which entail important spillover effects, a jurisdiction mainly ignore social benefits to other jurisdictions: the social MVPF is understated by the local MVPF.

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. Section 6.1 discusses estimation of mobility and capitalization effects. Section 6.2 describes how congestion effects have been estimated in the literature. Section 6.3 discusses how fiscal externalities and public services spillovers can be estimated. Section 6.4 proposes an approach to estimating social weights necessary to convert the MVPFs into welfare terms.

6.1. How to Estimate Mobility and Capitalization Effects?

6.1.1. Can Behavioral and Mobility Effects Be Estimated Jointly?

Initially, consider a case with a single taxing instrument on labor (as in Hendren and Sprung-Keyser, 2020) 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 mechanical effect, the behavioral effect, the price effect, and the mobility effect can be combined into $-n_i w_i \ell_i - n_i t_i^\ell w_i \frac{\partial \ell_i}{\partial t_i^\ell} - n_i t_i^\ell \ell_i \frac{\partial w_i}{\partial t_i^\ell} - t_i^\ell w_i \ell_i \frac{\partial n_i}{\partial t_i^\ell}$. Applying the product rule, one can easily see that this is the derivative of labor tax revenues or alternatively of the labor tax base: $\frac{\partial(t_i^\ell n_i w_i \ell_i)}{\partial t_i^\ell} =$

$n_i w_i \ell_i + t_i^\ell \frac{\partial(n_i w_i \ell_i)}{\partial t_i^\ell}$. Thus, ignoring the mechanical effect, 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 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.

6.1.2. 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, or ETI (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 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.

6.1.3. 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.

6.2. 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_i is the number of units provided by locality i and g_i 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. 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.

6.3. How to Estimate Interjurisdictional Externalities?

6.3.1. Estimating 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 (22) and (25), 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 $I-1$ other jurisdiction in the country separately. But as indicated in (25), 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 base or expenditure for jurisdiction j can be written as $b_j = b(\tau_j, \boldsymbol{\tau}_{-j}, X_j)$, where τ_j is the policy in the jurisdiction, $\boldsymbol{\tau}_{-j}$ 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:

$$b_{jt} = \alpha\tau_{jt} + \sum_{k\neq j}\beta_k\tau_{kt} + X_{jt}\gamma + \epsilon_{jt} \tag{46}$$

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. A sufficient number of exogenous sources of variation and a large number of observations 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 the sum of external effects $\sum_{j \neq i} E^j_{\tau_i}$ can be rewritten as $(I-1)\overline{E}_{\tau_i}$ where $\overline{E}_{\tau_i}$ is the mean external effect and I is the total number of jurisdictions in the economy. Then, the researcher needs to simply take care 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.

6.3.2. Estimating 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 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:

$$V_{hj} = \alpha + \beta g_j + \gamma t_j + \delta X_{hj} + \varepsilon_{hj}, \tag{47a}$$

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 (section 5.1).

We can apply the same procedure to estimate the "spillover" benefits from public goods provided in neighboring jurisdictions. Then, we can amend (47a) to include public goods in other jurisdictions giving:

$$V_{hj} = \alpha + \beta_j g_j + \sum_{k \neq j} \beta_k g_k + \gamma T_j + \delta X_{hj} + \varepsilon_{hj}, \tag{47b}$$

In (47b) 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 (section 6.3.1).

6.4. How to Estimate the Social Welfare Weights?

Converting the social MVPF into social welfare (section 4.2) requires taking a stance on the weight that the federal planner assigns to each jurisdiction: the jurisdiction-specific marginal social utility of income η_i. 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, we need to determine the cost, $g(y)$, of giving that group a tax cut of \$1. 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 $g(y) = 1 + FE(y)$ where $FE(y)$ 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

$$\frac{\eta^*(y)}{g(y)} = \kappa, \ \forall \ y \tag{48}$$

From (48) it follows that the social welfare weight associated with income of y, $\eta^*(y)$, 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 operationalize 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 (48), the social welfare weight on low income households is 1.77 times greater than that for the high income household.

Hendren's (2020) application determines social welfare weights for individual households of differing income. Our interest, however, is not in comparing welfare across individuals but across jurisdictions as required to determine the $SMVPF$ in (25). 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, $\eta_i \equiv \eta^* (\overline{y_i})$ where $\overline{y_i}$ is the average income in the jurisdiction. Alternatively, one could determine the average social welfare weight in the jurisdiction, $\eta_i \equiv \int_{\underline{y}}^{\overline{y}} f(y)\eta^i (y)\, dy$ 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.[40]

7. Empirical Applications

In this section, we conduct calibration exercises similar to Hendren and Sprung-Keyser (2020) by taking estimates of various elasticities and causal effects from the literature to estimate the local and social MVPFs of various policies. We use the parametric bootstrap to construct confidence intervals on the estimates.

Please note that this section is still a work in progress and, therefore, the results should be viewed as preliminary.

7.1. Decentralized Wealth Taxation and Fraudulent Relocations

Historically, Spain operated a progressive centralized taxation on wealth. However, starting in 2011, the wealth tax was decentralized to the regions. In the absence of regional autonomy, a "default" schedule set by the centralized government prevailed. However, regions were able to deviate from the schedule. While some regions took not action, some regions also raised marginal tax rates by a small amount. Only the region of Madrid lowered the wealth tax schedule, with Madrid zeroing out

[40] 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).

all tax liability for its residents. Thus, the salient tax differential in Madrid is well characterized as the difference between Madrid and all other regions. Wealth taxes as well as other income taxes follow the residence principle, so taxes can be avoided by moving to — or falsely declaring — Madrid. Agrawal et al. (2021) estimate various causal effects of Madrid's zero tax rate. We use these estimates plus summary statistics from their administrative data on wealth and income taxes.

To evaluate the closed, local (Madrid's), and social MVPF we consider treatment as Madrid's deviation to zero from the centralized default schedule. To construct this MVPF we assume that each region obtains revenue from labor income taxes, capital income taxes, and wealth taxes. We do not have data on other regional taxes, but these three taxes represent over 90% of regional revenue as property taxes mainly accrue to localities. We consider the same five year horizon studied in Agrawal et al. (2021) and follow Hendren and Sprung-Keyser (2020) using a 3% discount rate. Acknowledging our model does not have a wealth tax, its MVPF would be similar to other household taxes.

Closed MVPF. Letting the subeffects be denoted in Euros per initial wealth tax resident of Madrid, if one considered Madrid a closed-economy, then the MVPF is given by (23).

$$MVPF^{\mathrm{C}i}_{\tau_i} = \frac{\mathrm{DE}^i_{\tau_i}}{\mathrm{ME}^i_{\tau_i} + \mathrm{BE}^i_{\tau_i},} = \frac{47,457}{47,457 - 1,154} = \underset{[1.020,1.029]}{1.025.} \tag{49}$$

The willingness to pay for the wealth tax decreases is equal to the taxes saved by Madrid adopting the zero tax rate instead of the default tax schedule. Using the wealth tax simulator from Agrawal et al. (2021), we determine the tax liabilities of each pre-reform resident of Madrid who was eligible to pay wealth taxes. Calculating this in each year and aggregating the discounted values over five years, the willingness to pay is €47,457 per resident. Given Madrid's tax rate is zero, this is also the mechanical effect. The lower wealth tax rate results in savings behavioral response that increase taxable wealth via capital accumulation. However, because the wealth tax rate is zero, the added wealth tax base does not increase wealth tax revenues. Nor does it affect labor income taxes, as most wealth tax filers are rentiers. But the expansion of capital does increase capital, which potentially translates into capital income tax revenues. To calculate the behavioral effect, we use the estimate (5.910, se: 0.813) of the elasticity of taxable wealth from Jakobsen et al. (2020). We then calculate the amount of capital income taxes in the data due to expansion of capital in Madrid, assuming capital gains on that added wealth are realized proportionally over time. Because the elasticity of taxable wealth is relatively small and most capital gains are not realized, this results in €1154 of added capital income tax revenue per resident. This yields a MVPF of slightly greater than unity, as for each euro spent by Madrid's government cutting its wealth tax, Madrid's residents are willing to pay €1.025,

Local MVPF of Madrid. Constructing the local MVPF for the region of Madrid yields:

$$MVPF^{i}_{\tau_i} = \frac{\text{DE}^{i}_{\tau_i}}{\text{ME}^{i}_{\tau_i} + \text{BE}^{i}_{\tau_i} + \text{HME}^{i}_{\tau_i}} = \frac{47,457}{47,457 - 1,154 - 1,611} = \underset{[1.043,1.082]}{1.062.} \tag{50}$$

To construct this, notice the direct effect, the mechanical effect, and the behavioral effect are the same as the closed economy case. The household mobility effect has revenue consequences. Because the wealth tax rate is zero, movers to Madrid contribute no wealth tax revenue. But, because labor and capital income taxes are also sourced to the same region, Madrid realizes a tax revenue gain. To calculate the magnitude of the effect we use the causal estimates that show the cumulative increase in Madrid's stock of high-wealth individuals increased 1.5% one year later, 3.2%, 6.4%, 7.9% and 8.5% by five years later. Then, using these causal effects and the baseline number of residents in Madrid prior to decentralization, we calculate the cumulative amount of new residents in Madrid each year. To obtain the added amount of capital and labor income tax revenue, we multiply this number by the average income taxes of movers to Madrid.[41] This yields €1,611 more revenue per initial resident. Note, the household mobility effect also includes congestion costs on public services. As wealth taxpayers have very high wealth, these individuals to not consume much public services and a re net payers into the system. Thus, marginal congestion costs are likely zero.

In the above calculation, the capitalization into wages and prices is zero. Why? Agrawal et al. (2021) show that only the tax differential with Madrid matters, and provide evidence that the "moves" are fraudulent rather than real. In other words, high wealth taxpayers simply switch their primary residence to a second home they already have. Further, these households represent less than 1% of the population. Thus, there is likely minimal house price capitalization. Moreover, these households are rentiers (mostly senior citizen) and thus wages are unlikely to adjust. Finally, we assume no effects on profits or firm mobility due to household wealth taxes. While it is conceivable business profits could be affected, given the moves are not real, this is also consistent with residents of Madrid not owning out-of-region businesses that high wealth individuals hold.[42]

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

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

The local MVPF of Madrid (50) exceeds the closed economy MVPF (49) by €0.037, and their confidence intervals do not overlap. This is because the mobile tax base spurs added tax revenue for Madrid from other tax instruments.

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

$$SMVPF_{\tau_i} = \frac{WTP^i_{\tau_i} + \sum_{j \neq i} WTP^j_{\tau_i}}{G^i_{\tau_i} + \sum_{j \neq i} G^j_{\tau_i}} = \frac{47,457}{44,692 + 2,767} = \underset{[.974,1.027]}{0.999}. \tag{51}$$

Focus first on the denominator. The first term is obtained from (50). The other non-zero term is the household mobility effect. Other regions of Spain lose wealth tax revenue, labor income tax revenue and capital income tax revenue. To obtain these, we use the causal estimates of the movers, and use a wealth tax simulator to calculate what their liabilities would have been had they stayed in their home region and faced that region's wealth tax simulator. Taking the average counterfactual taxes paid by a mover to Madrid, which assumes tax-induced moves to Madrid are proportional to all moved to Madrid,[43] we aggregate over the five years, to find a discounted loss of €1,124 in wealth tax revenue. In other words, even though movement to Madrid increases its tax base by 8.5%, the decrease to the rest of Spain is much smaller because Madrid is only a small fraction of all of Spain. In addition, the other regions use personal income tax revenues from labor and capital. As the capital tax schedule in all regions is the same, this is simply the causal estimate of the number of movers times the average capital taxes paid by movers to Madrid. The same is true for labor income taxes, but labor income tax rates differ across regions, so we adjust these upward by the average differential, though this differential is quite small for a rentier with limited labor income. This yields personal income tax losses of €1,642. As is clear, income taxes are mainly a transfer between the rest of Spain and Madrid and so this cancels the household mobility effect in Madrid's fiscal net cost. The loss in wealth tax revenue to the rest of Spain is, by coincidence, similar to the behavior effect gain in Madrid.

Other than the household mobility effect, the other terms are again zero. As discussed, because moves are fraudulent, there are no pricing effects. We assume no effect on profits. Moreover, a tax change in Madrid does not affect the behavior of nonresidents, nor does it have a mechanical effect on the budget of other regions.

For the above reasons, especially with respect to the government budgets, the social MVPF is

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

very close to 1, the closed economy MVPF. Critically, for our purposes, the SMVP is significantly lower than the local MVPF of Madrid, highlighting the importance of interjurisdictional policy spillovers for welfare analysis.

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

Of course, one interesting point is whether taxed have a direct effect of the willingness to pay of nonresidents. Theoretically, for a marginal change, there would be no effect. However, because our change is discrete, nonresident movers may have a positive willingness to pay for Madrid's low-tax deviation. In particular, Madrid's policy change can be viewed as a tax avoidance service for high wealth individuals outside of Madrid. If one took this view, then we can calculate the willingness to pay of nonresidents who avail themselves of this service. Given evasion comes with risk, the willingness to pay needs to be adjusted by the audit probability (approximately 1.5%) and the fine (100% of evaded taxes). This gives an expected value for the direct external effect of €1074, which would then yield an external MVPF value of 0.39. Of course, given this is fraud, a social planner may want to give zero weight to this. But if the planner gives full weight to it, then the SMVPF becomes 1.02, as the costs to the government are mainly transfers among the regions, but the zero tax rate in Madrid benefits nonresidents of Madrid by providing a means to avoid taxes.

7.2. Bidding for Firms

The practice of states and local governments to "bid for firms," that is, to provide subsidies, tax concessions, worker training, and public services to attract large employers is an example of how local and social MVPF may differ for a policy, in this case, the bid (subsidy) for a firm. Generally, these efforts by state and local governments — in most cases the bids involve both levels of government — are an effort to increase employment and earnings in the locality in which the firm may locate its new plant. For our discussion here, we focus on states and their policies.

In this section, we consider a bid — in the form of firm-specific subsidies — by the state of Tennessee for the new 2008 Volkswagen (VW) plant, conditional on the bids of other states. Taking as given that regardless of what it does, other states will bid, should Tennessee enter the bidding competition based on its local MVPF and the social MVPF? If Tennessee makes a bid, consistent with the observed outcome, it wins the plant; if it does not, then the bid will go to the observed runner-up. By conditioning on the other bids, this is the MVPF of Tennessee's unilateral decision to bid and is not the MVPF of all bidding or of eliminating bidding. The VW subsidy competition is a prominent example of bidding for firms, was a very large subsidy deal, and has been highlighted in the prior literature (Slattery and Zidar, 2020). A purpose of this section is to highlight the diffrence in the social and local MVPF, but also to demonstrate to researchers how estimating all of the individual components of the MVPF can be simplified extensively using the auction structure.

Much of the literature on bidding for firms has focused on the competition between the winning "bidder," the state in which the firm decides to locate and the runner-up state (Slattery, 2020; Slattery and Zidar, 2020; Greenstone et al., 2010). External impacts of where a firm chooses to locate are not necessarily limited to the locality that it did not choose to locate, that is, the runner-up. However, the runner-up is presumably the alternative location, if the winning state did not bid. Hence, to determine the MVPF's for a bid by the winning state, we need to know the opportunity cost of that bid if the firm located in the runner-up state. We assume that ownership of the firm is distributed among all the states, so that the share in any one state (winner or runner-up) is negligible.

Following Slattery (2020), let v^i denote the value of the plant to state i. What effects of the firm's location do these bids reflect? The state's valuation of the plant certainly reflect benefits (willingness to pay) to current residents – increased employment, earnings, and appreciation in housing values. As well, these bids would presumably reflect how the location of the firm would affect net government costs. However, while increases in tax revenue from increases in employment, earnings and profits of current residents may increase government revenues, they are a cost to the residents. It follows, then, that these revenues are not reflected in the bid – the benefits of increased public expenditures and costs of taxes on current residents cancel. Revenue and costs from marginal new residents and firms do not enter the valuation because the government cares about the well-being of current residents. Finally, note that because the state has a negligible share of ownership of the firm, the direct effect—the extra profits equal to the value of the bid— accrues to the firm's owners not the state's residents. Then it follows that we can construct the local MVPF as:

$$MVPF^{TN} = \frac{v^{TN}}{b^{TN} + FE^{TN}}, \tag{52}$$

where FE is the fiscal externality, including behavioral, price and profit, and mobility effects.

Then, to obtain the social MVPF we need to determine the external benefit/cost. If Tennessee does not bid, then VW would locate in the runner-up state (AL), with a valuation of v^{AL} to its residents. From a social perspective, these are foregone benefits. Furthermore, because the firm is primarily owned by non-residents of TN, the external willingness-to-pay includes the gross profits inclusive of the Tennessee bid $\left(\pi^{TN} + b^{TN}\right)$ less the foregone profits from locating in the runner-up state $\left(\pi^{AL} + b^{AL}\right)$. Analogously, the external net cost to the government reflects the reduction in opportunity costs to Alabama, the mechanical cost (AL's bid), and the fiscal externalities in Alabama.

To simplify construction of social MVPF, we follow Slattery (2020) and treat the bidding process as an English auction. As Slattery explains (Slattery, 2020, p.20 - 21) there are several characteristics of the English auction that correspond to the typical bidding process for these plants. The form of this auction provides us with useful information on the relationship between the bids in the winning location (TN) and the runner-up (AL): $b^{TN} = \pi^{AL} - \pi^{TN} + b^{AL}$. Following her notation the bid is b^i and location-specific firm profits are π^i. This equation says that Tennessee's bid must marginally exceed the bid of Alabama and any differences in profits between the two states.

Then, the social MVPF simplifies to:

$$SMVPF = \frac{v^{TN} + \overbrace{\pi^{TN} + b^{TN} - \left(v^{AL} + \pi^{AL} + b^{AL}\right)}^{External}}{b^{TN} + FE^{TN} \underbrace{- \left(b^{AL} + FE^{AL}\right)}_{External}} = \frac{v^{TN} - v^{AL}}{b^{TN} + FE^{TN} - \left(b^{AL} + FE^{AL}\right).} \quad (53)$$

The form of (53) is elegant because estimating the numerator now simply requires knowing the valuation of the winner and runner-up, without separately needing to estimate the direct effect, the disposable income effect, and the profit effect.

Operationalizing MVPF for Subsidy Competition. Again, Slattery (2020) offers an approach to obtain these of valuations by exploiting firm-specific and state-specific information. In particular, she estimates

$$b_{p1} \;=\; \underbrace{\beta_p \left(x_2 - x_1\right) + \xi_{p2} - \xi_{p1}}_{\pi_{p2} - \pi_{p1}} + \underbrace{\alpha_1 x_2 + \alpha_2 z_p + \alpha_3 x_2 z_p + \varepsilon_{p2}}_{v_{p2}}, \quad (54)$$

where $i = 1$ denotes the winner and $i = 2$ denotes the runner-up, making b_{p1} the winning bid for plant p. Further, x_i are state-level characteristics and z_p are plant-level characteristics, and $\xi_{p2} - \xi_{p1} + \varepsilon_{p2}$ is a composite error term. We use her estimated values of the $\widehat{\alpha}'s$'s to construct the valuation of the plant by each state after evaluating the equation at its state/local characteristics.[44] Plugging in these predicted values into the local MVPF, will yield a willingness to pay that is too small because we do not observe ε_{p1} for TN, and because it is associated with the winning bid, it has an expectation that is positive. Similarly, because $\varepsilon_{p1} - \varepsilon_{p2} > 0$, we will also identify a lower bound for the social MVPF.

To obtain the denominator of the MVPF, we take two approaches. The first, utilizes *ex ante* available information from impact studies. The second, utilizes *ex post* information from causal estimates of winning the plant on economic outcomes. In both approaches, wages are calculated at the commuting-zone level for each state (Huntsville, AL vs. Chattanooga, TN) and allowed to appreciate using the sector-specific inflation rate. All streams of tax revenue are calculated as present discounted values over a twenty year horizon with a 3% discount rate.

Then, under the first approach, impact studies traditionally assume that all created jobs are new (additional) jobs and that each promised job has a multiplier effect on employment. We use the same multipliers as in Slattery (2020).[45] The promised jobs are assumed to have the local wage in the "transportation equipment manufacturing" sector (NAICS 336), but all other expected jobs are assumed to be at the per capita local income level. We then estimate discounted sales tax revenue and personal income tax revenue in each state from those created jobs. Sales taxes are calculated using the proportion of income spent by a typical consumer in the appropriate quantile of the income distribution.[46]

Under the causal estimates approach, we use the difference-in-differences estimate of the new jobs created by VW from Slattery and Zidar (2020): 3854 new jobs. In addition, these authors show that for the full sample of all bids they consider, that the overall employment levels of the winning jurisdictions do *not* increase. The implication is that added jobs in the transportation equipment manufacturing sector are offset in other sectors, without any noticeable multiplier effects. Then, the added sales and income tax revenue is only based on the difference in wages in VW's sector and average wages under this approach.

Under both approaches, there is no added corporate tax revenue because it is assumed that jurisdictions have included these as tax concessions for the firm. Moreover, a state like Tennessee

[44] When available, we take these characteristics from Slattery and Zidar (2020). For all other characteristics, we obtain them from the same sources listed in Slattery (2020).

[45] Economic Policy Institute. 2019. "Updated Employment Multipliers for the U.S. Economy."

[46] Institute on Taxation and Economic Policy (ITEP). 2018. "Who Pays?: A Distributional Analysis of the Tax System in All Fifty States".

has a 100% sales based apportionment formula for manufacturing, implying that revenue accrues to the state regardless of where production occurs. Moreover, in both approaches we account for VW's voluntary contributions to the local education system.

Using Slattery and Zidar (2020)'s estimating equation to predict the valuation of the VW plant, yields a valuation of \$227 million to TN and \$210 million to AL. Constructing the denominator, the realized bids are costs of \$558 million and \$386 in each state. Then, the local MVPF from an ex ante (impact study) perspective and an ex post (causal effect) perspective are:

$$LMVPF^{TN}_{impact} = \frac{227}{558 - 1583} = \underset{[\infty,\infty]}{\infty} \qquad LMVPF^{TN}_{causal} = \frac{227}{558 - 57} = \underset{[0.101,2.864]}{0.458}$$

where the fiscal externality is calculated as described above. In the impact studies, VW promised 2000 new jobs, which earn an industry wage of initially \$50,500 in that metro area. Using the jobs multiplier for the sector, 14.28, implies many additional jobs that we assume are at a mean wage of initially \$39,400. Because these are assumed to be new jobs in the impact studies, they contribute additional sales tax revenue on the entire income. For these income groups, that implies revenue that is 6.7% of income.[47] Because Tennessee has no income tax, no additional income tax revenue arises. Finally, as discussed above, attracting VW raises no additional corporate tax revenue, except on any added profitability from locating in Tennessee relative to Alabama. As can be seen, the impact study estimates imply the added tax revenue more than pays for the bid, resulting in an infinite MVPF. This is consistent with politicians using these impact studies to justify bidding for the plant.

The causal estimates suggest a different story. Slattery and Zidar (2020) estimate an additional 3854 jobs for the VW case, and show that on average, the overall increase in jobs in winning counties is negligible. As a result, the fiscal externality on sales tax revenue is calculated based on the wage increase for each job. This, combined with the voluntary contributions to education, only offset the bid by \$57 million. Slattery and Zidar (2020) also show house prices decrease, suggesting this number is even smaller due to declines in property tax revenue, but we do not make this adjustment because its unlike assessed values fell so much due to persistence in the assessment process. Thus, the ex post MVPF is 0.458. Keep in mind that because we use only the predicted component of (54) and do not include the structural error term, which has a positive expected value, we underestimate the numerator and thus the MVPF.[48]

[47] This approach misses any added sales tax revenue on business-to-business purchases made by VW that are subject to the sales tax.

[48] When implementing the parametric bootstrap to obtain confidence bands, the predicted valuation could be

To construct the social MVPF, we following the same procedure accounting for the opportunity cost and benefit on Alabama. When calculating the fiscal externality, Alabama has an income tax and so it obtains both sales and income tax revenue.[49] Because Alabama's tax rates and income levels are different, the present discounted value of the added revenue is different than in Tennessee. The social MVPF becomes:

$$SMVPF_{impact} = \frac{227 - 210}{(558 - 1583) - (386 - 1890)} = \underset{[-0.169, 0.155]}{0.035}$$

$$SMVPF_{causal} = \frac{227 - 210}{(558 - 57) - (386 - 156)} = \underset{[-0.303, 0.278]}{0.063}$$

Both social MVPFs make a striking point: compared to both local MVPFs, the social MVPFs are close to zero. While the local MVPF using impact study estimates suggest the bid pays for itself, the social planner views the bid highly unfavorably. The intuition is simple: the local planner believes the fiscal externality accrues to Tennessee with no cost elsewhere, but the social planner sees the revenue gain of Tennessee as simply a transfer of revenue that would have accrued to the runner up (e.g., "stealing" from Alabama). This combined with the fact that the valuation of the plant in both states is similar,[50] implies a social planner would not support the bid, even though a local planner would view the bid as highly cost-effective ex ante. Ex post, the social and local are closer, but still the state of Tennessee's MVPF is much larger than the social.

Bidding for firms provides two insights into our theory. First, the local and social MVPF can diverge substantially, with one being infinite even when the other is near zero. Second, the structure of subsidy competition and the information revealed in the English auction operationalize our MVPF without needing to estimate the different components of the willingness to pay separately.

7.3. K-12 Education Spending

Next, 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 local and social MVPFs.

negative for some draws. However, the valuation inclusive of the structural error term must be positive, or the state would not bid, so we drop these predicted negative valuations when creating the confidence interval.

[49] Alabama's corporate tax does not entirely weight sales, and so its corporate tax would be affected by winning the plant. However, the concessions usually reduce corporate tax liability.

[50] Even though the valuation in each state must be positive, the difference in the valuation may be negative, and thus the confidence intervals on the social MVPF can include zero.

7.4. Higher Education Scholarship Programs

As a second expenditure example, we plan to study the effect of state university scholarships such as the Georgia HOPE program. In particular, because these programs are aimed at preventing students from moving during college, but because college students are highly mobile after graduation, college education likely has important spillover benefits.

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. 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 nationally. Our paper provides a comprehensive framework for this.

References

Agersnap, O., A. Jensen, and H. Kleven (2020). The welfare magnet hypothesis: Evidence from an immigrant welfare scheme in Denmark. *American Economic Review: Insights 2*(4), 527–42.

Agrawal, D. R., D. Foremny, and C. Martínez-Toledano (2021). Paraisos fiscales, wealth taxation and mobility.

Agrawal, D. R., W. H. Hoyt, and J. D. Wilson (2020). Local policy choice: Theory and empirics. *Journal of Economic Literature*.

Ahlfeldt, G. M., S. J. Redding, D. M. Sturm, and N. Wolf (2015). The economics of density: Evidence from the Berlin Wall. *Econometrica 83*(6), 2127–2189.

Atkinson, A. B. and N. H. Stern (1974). Pigou, taxation and public goods. *The Review of Economic Studies 41*(1), 119–128.

Auerbach, A. J. (1985). The theory of excess burden and optimal taxation. In *Handbook of Public Economics*, Volume 1, pp. 61–127. Elsevier.

Auerbach, A. J. and J. R. Hines, Jr. (2002). Taxation and economic efficiency. In *Handbook of Public Economics*, Volume 3, pp. 1347–1421. Elsevier.

Bergstrom, T. C. and R. P. Goodman (1973). Private demands for public goods. *The American Economic Review 63*(3), 280–296.

Black, D. A. and W. H. Hoyt (1989). Bidding for firms. *American Economic Review 79*(5), 1249–1256.

Borcherding, T. E. and R. T. Deacon (1972). The demand for the services of non-federal governments. *American Economic Review 62*(5), 891–901.

Brueckner, J. K. (1981). Congested public goods: The case of fire protection. *Journal of Public Economics 15*(1), 45–58.

Brueckner, J. K. (2000). Welfare reform and the race to the bottom: Theory and evidence. *Southern Economic Journal 66*(3), 505–525.

Brueckner, J. K. (2003). Strategic interaction among governments: An overview of empirical studies. *International Regional Science Review 26*(2), 175–188.

Buettner, T. (2003). Tax base effects and fiscal externalities of local capital taxation: Evidence from a panel of German jurisdictions. *Journal of Urban Economics 54*(1), 110–128.

Case, A. C., H. S. Rosen, and J. R. Hines Jr. (1993). Budget spillovers and fiscal policy interdependence: Evidence from the states. *Journal of Public Economics 52*(3), 285–307.

Ciccone, A. and R. E. Hall (1996). Productivity and the density of economic activity. *American Economic Review 86*(1), 54–70.

Dahlby, B. (2008). *The Marginal Cost of Public Funds*. Cambridge, MA: The MIT Press.

Duncombe, W. and J. Yinger (1993). An analysis of returns to scale in public production, with an application to fire protection. *Journal of Public Economics 52*(1), 49–72.

Epple, D., A. Jha, and H. Sieg (2014, March). The superintendent's dilemma: Managing school district capacity as parents vote with their feet. Conference Working Paper.

Epple, D. and R. Romano (2003). Neighborhood Schools, Choice, and the Distribution of Educational Benefits. In C. M. Hoxby (Ed.), *The Economics of School Choice*, pp. 227–286. University of Chicago Press.

Epple, D., T. Romer, and H. Sieg (2001). Interjurisdictional sorting and majority rule: An empirical analysis. *Econometrica 69*(6), 1437–1465.

Etzel, T., S. Siegloch, and N. Wehrhöfer (2021). Direct, spillover and welfare effects of regional firm subsidies. Working Paper.

Fajgelbaum, P. D., E. Morales, J. C. Suárez Serrato, and O. Zidar (2019). State taxes and spatial misallocation. *The Review of Economic Studies 86*(1), 333–376.

Feldstein, M. and M. V. Wrobel (1998). Can state taxes redistribute income? *Journal of Public Economics 68*, 369–396.

Finkelstein, A. and N. Hendren (2020). Welfare analysis meets causal inference. *Journal of Economic Perspectives 34*(4), 146–67.

Fuest, C., A. Peichl, and S. Siegloch (2018). Do higher corporate taxes reduce wages? micro evidence from germany. *American Economic Review 108*(2), 393–418.

Fullerton, D. (1991). Reconciling recent estimates of the marginal welfare cost of taxation. *The American Economic Review 81*(1), 302–308.

Greenstone, M., R. Hornbeck, and E. Moretti (2010). Identifying agglomeration spillovers: Evidence from winners and losers of large plant openings. *Journal of Political Economy 118*(3), 536–598.

Harberger, A. (1964). *The Role of Direct and Indirect Taxes in the Federal Reserve System*, Chapter Taxation, Resource Allocation, and Welfare, pp. 25 – 80. Princeton University Press.

Hendren, N. (2016). The policy elasticity. *Tax Policy and the Economy 30*(1), 51–89.

Hendren, N. (2020). Measuring economic efficiency using inverse-optimum weights. *Journal of Public Economics 187*, 104198.

Hendren, N. and B. Sprung-Keyser (2020). A unified welfare analysis of government policies. *The Quarterly Journal of Economics 135*(3), 1209–1318.

Jackson, C. K., R. C. Johnson, and C. Persico (2016). The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. *Quarterly Journal of Economics 131*(1), 157–218.

Jakobsen, K., K. Jakobsen, H. Kleven, and G. Zucman (2020). Wealth taxation and wealth accumulation: Theory and evidence from Denmark. *The Quarterly Journal of Economics 135*(1), 329–388.

Kleven, H., C. Landais, M. Muñoz, and S. Stantcheva (2020). Taxation and migration: Evidence and policy implications. *Journal of Economic Perspectives 34*(2), 119–142.

Kleven, H. J. (2021). Sufficient statistics revisited. *Annual Review of Economics 13*, 515–538.

Kleven, H. J. and C. T. Kreiner (2006). The marginal cost of public funds: Hours of work versus labor force participation. *Journal of Public Economics 90*(10-11), 1955–1973.

Kline, P. and E. Moretti (2014). People, places, and public policy: Some simple welfare economics of local economic development programs. *Annual Review of Economics 6*(1), 629–662.

Löffler, M. and S. Siegloch (2021). Welfare effects of property taxation. Working Paper.

Mast, E. (2019). Race to the bottom? local tax break competition and business location. *American Economic Journal: Applied Economics 12*(1), 299–317.

Matsumoto, M. (2000). A tax competition analysis of congestible public inputs. *Journal of Urban Economics 48*(2), 242–259.

Mayshar, J. (1990). On measures of excess burden and their application. *Journal of Public Economics 43*(3), 263–289.

Mirrlees, J. A. (1972). The optimum town. *Swedish Journal of Economics 74*(1), 114–135.

Moretti, E. (2011). Local labor markets. In *Handbook of labor economics*, Volume 4, pp. 1237–1313. Elsevier.

Oates, W. E. (1969). The effects of property taxes and local public spending on property values: An empirical study of tax capitalization and the Tiebout hypothesis. *Journal of Political Economy 77*(6), 957–971.

Oates, W. E. (1972). *Fiscal Federalism*. Harcourt, Brace Jovanovich. New York.

Oates, W. E. (1988). On the measurement of congestion in the provision of local public goods. *Journal of Urban Economics 24*(1), 85–94.

Poterba, J. M. (1996). Retail price reactions to changes in state and local sales taxes. *National Tax Journal 49*(2), 165–176.

Richter, W. F. and D. Wellisch (1996). The provision of local public goods and factors in the presence of firm and household mobility. *Journal of Public Economics 60*(1), 73–93.

Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy 90*(6), 1257–1278.

Rosen, H. S. and T. Gayer (2014). *Public Finance*. McGraw Hill.

Rosenthal, S. S. and W. C. Strange (2008a). The attenuation of human capital spillovers. *Journal of Urban Economics 64*(2), 373–389.

Rosenthal, S. S. and W. C. Strange (2008b). The attenuation of human capital spillovers. *Journal of Urban Economics 64*(2), 373–389.

Saez, E., J. Slemrod, and S. H. Giertz (2012). The elasticity of taxable income with respect to marginal tax rates: A critical review. *Journal of Economic Literature 50*(1), 3–50.

Scotchmer, S. (2002). Local public goods and clubs. *Handbook of Public Economics 4*, 1997–2042.

Slattery, C. and O. Zidar (2020). Evaluating state and local business tax incentives. *Journal of Economic Perspectives 34*(2), 90–118.

Slattery, C. R. (2020, March). Bidding for firms: Subsidy competition in the U.S. UVA Working Paper.

Slemrod, J. and S. Yitzhaki (1996, March). The cost of taxation and the marginal efficiency cost of funds. *IMF Staff Papers 43*(1), 172–198.

Slemrod, J. and S. Yitzhaki (2001). Integrating expenditure and tax decisions: The marginal cost of funds and the marginal benefit of projects. *National Tax Journal 54*(2), 189–202.

Stiglitz, J. E. and P. Dasgupta (1971). Differential taxation, public goods and economic efficiency. *Review of Economic Studies 38*(2), 151–174.

Suárez Serrato, J. C. and O. Zidar (2016). Who benefits from state corporate tax cuts? A local labor markets approach with heterogeneous firms. *American Economic Review 106*(9), 2582–2624.

Suárez Serrato, J. C. and O. Zidar (2018). The structure of state corporate taxation and its impact on state tax revenues and economic activity. *Journal of Public Economics 167*, 158–176.

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of Political Economy 64*(5), 416–424.

Wellisch, D. (1996). Decentralized fiscal policy with high mobility reconsidered: Reasons for inefficiency and an optimal intervention scheme. *European Journal of Political Economy 12*(1), 91–111.

Wildasin, D. (1986). Spatial variation of the marginal utility of income and unequal treatment of equals. *Journal of Urban Economics 19*, 125–129.

Wildasin, D. E. (1979). Public good provision with optimal and non-optimal commodity taxation: The single-consumer case. *Economics Letters 4*(1), 59–64.

Wildasin, D. E. (1980). Locational efficiency in a federal system. *Regional Science and Urban Economics 10*, 453–471.

Wildasin, D. E. (1984). On public good provision with distortionary taxation. *Economic Inquiry 22*(2), 227–243.

Wildasin, D. E. (1989). Interjurisdictional capital mobility: Fiscal externality and a corrective subsidy. *Journal of Urban Economics 25*(2), 193–212.

Wildasin, D. E. (2021). Open-economy public finance. *National Tax Journal 74*(2), 467–490.

Wilson, J. D. (1986). A theory of interregional tax competition. *Journal of Urban Economics 19*(3), 296–315.

Wilson, J. D. (1995). Mobile labor, multiple tax instruments, and tax competition. *Journal of Urban Economics 38*(3), 333–356.

Zodrow, G. R. and P. Mieszkowski (1986). Pigou, Tiebout, property taxation, and the underprovision of local public goods. *Journal of Urban Economics 19*, 356–370.

Appendix

A. MVPF and welfare

A.1. Local and external MVPF

Given that the local governments account for the welfare of the households residing on their territories before the policy change, the local welfare of jurisdiction j is:

$$W_j \equiv \bar{n}_j V_j \tag{A.1}$$

where $\bar{n}_j$ is the exogenous initial population of the jurisdiction. As we are interested in small policy changes, the initial population $\bar{n}_j$ will ex-post coincide with the equilibrium population. Differentiating (A.1), it follows that the net impact of a change in the policy instrument τ_i on the local welfare is:

$$\frac{\partial W_j}{\partial \tau_i} = \lambda_j \frac{\bar{n}_j}{\lambda_j} \frac{\partial V_j}{\partial \tau_i} = \lambda_j WTP^j_{\tau_i} \tag{A.2}$$

where λ_j is the marginal utility of income of the residents of j and $WTP^j_{\tau_i}$ is their marginal willingness to pay for policy $\mathrm{d}\tau_i$. It follows that the local marginal welfare is proportional to the marginal willingness to pay. Denoting, again, G_j the local deficit of jurisdiction j, the marginal deficit of jurisdiction j is as denoted previously:

$$\frac{\partial G_i}{\partial \tau_i} = G^j_{\tau_i}$$

Combining equations (A.2) and (A.1), the effect on local welfare per dollar of policy $\mathrm{d}\tau_i$ on policy j is:

$$MW^j_{\tau_i} \equiv \frac{\frac{\partial W_j}{\partial \tau_i}}{\frac{\partial G_i}{\partial \tau_i}} = \lambda_j MVPF^j_{\tau_i} \tag{A.3}$$

which proves condition (24).

A.2. Social MVPF

The social welfare function is:

$$SW = \sum_j \psi_i \bar{n}_j V_j \tag{A.4}$$

Differentiating it with respect to τ_i, we obtain:

$$\frac{\partial SW}{\partial \tau_i} = \sum_j \psi_j \lambda_j \frac{\bar{n}_j}{\lambda_j} \frac{\partial V_j}{\partial \tau_i} = \sum_j \psi_j \lambda_j WTP^j_{\tau_i} = \sum_j \psi_j \lambda_j \sigma^j_{\tau_i} \sum_k WTP^k_{\tau_i}$$

where $\sigma^j_{\tau_i} \equiv WTP^j_{\tau_i} / \sum_k WTP^k_{\tau_i}$ is the share of jurisdiction j in the aggregate willingness to pay of the economy. Then:

$$\frac{\partial SW}{\partial \tau_i} = \eta_{\tau_i} \sum_j WTP^j_{\tau_i} \tag{A.5}$$

where the average social marginal utility of the beneficiaries of the policy is denoted:

$$\eta_{\tau_i} \equiv \sum_j \psi_j \lambda_j \sigma^j_{\tau_i} \tag{A.6}$$

Denoting, again, $SG = \sum_i G_i$ the local deficit of jurisdiction j, the marginal social deficit of jurisdiction j is as denoted previously:

$$\frac{\partial SG}{\partial \tau_i} = \sum_j \frac{\partial G_j}{\partial \tau_i} = \sum_j G^j_{\tau_i} \tag{A.7}$$

Combining equations (A.5) and (A.7), the effect on social welfare per dollar of policy $\mathrm{d}\tau_i$ on policy j is:

$$\frac{\frac{\partial SW}{\partial \tau_i}}{\frac{\partial SG}{\partial \tau_i}} = \eta_{\tau_i} SMVPF_{\tau_i}$$

which proves condition (26).

B. 2-jurisdiction general equilibrium

The purpose of this appendix is to prove the results stated in section 5.2.

B.1. Wage and Rent as a Function of the Local Population

The housing market equilibrium in jurisdiction i (6a) can be written as $n_i = H_i(p_i)$, which implicitly defines the housing rent p_i as a function of the population. Implicitly differentiating this housing market clearing condition, we obtain:

$$\frac{\partial p_i}{\partial n_i} = \frac{1}{H_i'(p_i)} > 0, \tag{A.8}$$

which indicates that an increase in population, that is an increase in housing demand, exerts an upward pressure on the housing rent.

Let us now turn to the labor market. A firm in jurisdiction i chooses its labor demand l_i so as to maximize its profit $\pi_i = f_i(l_i, L_i) - w_i l_i$ and thus satisfy the first-order condition: $\partial f_i/\partial l_i(l_i, L_i) = w_i$ (eq.a). Given that each workers supplies one unit of labor, the workforce of jurisdiction i is its population, i.e. $L_i = n_i$ (eq.b). It follows that the labor market clearing condition, $L_i = m_i l_i$ can be equivalently written as $l_i = n_i/m_i$ (eq.c). Inserting (eq.b) and (eq.c) into the firm's first-order condition (eq.a) entails $\partial f_i/\partial l_i(n_i/m_i,\, n_i) = w_i$ which implicitly defines the wage w_i as a function of the population n_i. Implicitly differentiating this condition, we obtain:

$$\frac{\partial w_i}{\partial n_i} = \alpha_i - \beta_i \quad \equiv \psi_i \tag{A.9}$$

where $\alpha_i \equiv \partial^2 f_i/\partial L_i \partial l_i > 0$ and $\beta_i \equiv -\frac{1}{m_i}\partial^2 f_i/\partial l_i^2 > 0$. It follows from (A.9) that $\partial w_i/\partial n_i$ might be positive or negative depending on whether agglomeration economies α_i outweigh decreasing marginal returns β_i or not.[51] In the absence of agglomeration economies ($\alpha_i = 0$), the wage is a decreasing function of the population. However, if agglomeration economies are large enough ($\alpha_i > \beta_i$), the wage increases with respect to the population.

B.2. Derivation of the responses

The population conditions can be written as:

$$n_1 = \frac{N}{1 + \exp(\mu \Delta V)} \tag{A.10}$$

$$n_1 + n_2 = N \tag{A.11}$$

[51] For example, assuming a quadratic production function $f_i = aL_i l_i + bl_i - \gamma c l_i^2/2$, we have $\alpha_i = am_i$ and $\beta_i = c$.

where $\Delta V = V_2 - V_1$ and the indirect utility (3) is:

$$V_i = U\left(\frac{1}{1+t_i^x}[(1-t_i^\ell)w_i - t_i^n - (1+t_i^h)p_i], g_i, g_{-i}\right) \qquad i = 1,2 \tag{A.12}$$

The equilibrium conditions reduce to condition (A.10) in which we plug $n_2 = N - n_1$ from (A.11). 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.10) with respect to policy instrument $\tau \in \mathbf{P}$, we obtain the general equilibrium responses:

$$\frac{\partial n_1}{\partial \tau} = -\frac{\mu n_1 n_2}{N}\left(\frac{\partial \Delta V}{\partial n_1}\frac{\partial n_1}{\partial \tau} + \frac{\partial \Delta V}{\partial \tau}\right) \qquad \text{so that,} \qquad \frac{\partial n_1}{\partial \tau} = -\frac{\mu \dfrac{\partial \Delta V}{\partial \tau}}{\dfrac{N}{n_1 n_2} + \mu \dfrac{\partial \Delta V}{\partial n_1}} \tag{A.13}$$

from which we obtain the general equilibrium responses:

$$\frac{\partial n_1}{\partial t_1^b} = -\frac{\mu n_1 n_2 \mathrm{B}_1^b\,(1+t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{A.14}$$

$$\frac{\partial n_1}{\partial g_1} = \frac{\mu n_1 n_2 (1+t_1^x)(1+t_2^x)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right) \qquad > 0, \tag{A.15}$$

where

$$D \equiv n_1 n_2\left[\frac{N(1+t_1^x)(1+t_2^x)}{n_1 n_2} - \mu \sum_{i=1,2}\left(1+t_{-i}^x\right)\frac{\partial U_i}{\partial x_i}\mathrm{IE}_{n_i}^i\right] > 0$$

with

$$\mathrm{IE}_{n_i}^i \equiv (1+t_i^h)\frac{\partial p_i}{\partial n_i} - (1-t_i^\ell)\frac{\partial w_i}{\partial n_i}$$

The positive sign of D is guaranteed by assuming that agglomeration economies are not too strong. Specifically, for each $i = 1,2$ and $j = 1,2$ with $j \neq i$:[52]

$$\mathrm{IE}_{n_i}^i < \frac{N\left(1+t_i^x\right)}{2\mu n_i n_j \dfrac{\partial U_i}{\partial x_i}} \tag{A.16}$$

[52] In the case of household perfect mobility ($\mu \to \infty$), condition (A.16) reduces to $(1-t_i^\ell)\frac{\partial w_i}{\partial n_i} - (1+t_i^h)\frac{\partial p_i}{\partial n_i} < 0$, which guarantees stability of the location equilibrium. In our model, stability is guaranteed by the idiosyncratic taste of individuals for locations, but condition (A.16) guarantees economically meaningful responses of population to policy changes.

where $\partial w_i/\partial n_i$ and $\partial p_i/\partial n_i$ are as defined in (A.8) and (A.9). Assumption (A.16) 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 ($\psi_i < 0$), we have $\mathrm{d}w_i/\mathrm{d}n_i \leq 0$ from (A.9), so that condition (A.16) immediately holds since rent is an increasing function of population and the right-hand side of (A.16) is strictly positive. Thus, this assumption is only necessary in the case of agglomeration economies.

Let us turn to the responses of the consumption x_i to policy changes. Implicitly differentiating the household budget constraint and inserting (A.14)–(A.15), we obtain the general equilibrium responses:

$$\frac{\partial x_1}{\partial t_1^b} = -\frac{\mathrm{B}_1^b}{D}\left(N(1+t_2^x) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2}\mathrm{IE}_{n_2}^2\right) \quad <0 \tag{A.17}$$

$$\frac{\partial x_1}{\partial g_1} = \frac{\mu n_1 n_2 (1+t_2^x)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right)\mathrm{IE}_{n_1}^1 \tag{A.18}$$

the last response implies that:

$$\mathrm{sign}\left(\frac{\partial x_1}{\partial g_1}\right) = \mathrm{sign}\left(\mathrm{IE}_{n_1}^1\right) \tag{A.19}$$

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

$$\frac{\partial x_2}{\partial t_1^n} = \frac{\mu n_1 n_2 \frac{\partial U_1}{\partial x_1}}{D}\mathrm{IE}_{n_2}^2 \qquad \frac{\partial x_2}{\partial t_1^\ell} = \frac{\mu n_1 n_2 w_1 \frac{\partial U_1}{\partial x_1}}{D}\mathrm{IE}_{n_2}^2 \qquad \frac{\partial x_2}{\partial t_1^x} = \frac{\mu n_1 n_2 x_1 \frac{\partial U_1}{\partial x_1}}{D}\mathrm{IE}_{n_2}^2 \tag{A.20}$$

and:

$$\frac{\partial x_2}{\partial g_1} = -\frac{\mu n_1 n_2 (1+t_1^x)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right)\mathrm{IE}_{n_2}^2 \tag{A.21}$$

It follows that:

$$\mathrm{sign}\left(\frac{\partial x_2}{\partial t_1^b}\right) = -\mathrm{sign}\left(\frac{\partial x_2}{\partial g_1}\right) = \mathrm{sign}\left(\mathrm{IE}_{n_2}^2\right) \tag{A.22}$$

From conditions (A.14)–(A.22), it follows that in the case of household immobility, i.e. $\mu \to 0$,we have:

$$\frac{\partial n_1}{\partial t_1^b} \to 0, \quad \frac{\partial n_1}{\partial g_1} \to 0, \quad \frac{\partial x_1}{\partial t_1^b} \to -\frac{\mathrm{B}_1^b}{1+t_1^x} < 0, \quad \frac{\partial x_1}{\partial g_1} \to 0, \quad \frac{\partial x_2}{\partial t_1^b} \to 0, \quad \frac{\partial x_2}{\partial g_1} \to 0., \tag{A.23}$$

In sum, 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 $j \neq i$:

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

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 $\partial x_i/\partial g_j \to 0$.

C. Two-Jurisdiction Business Model

The purpose of this appendix is to prove the results stated in section 5.3.

C.1. Model and general equilibrium

The utility of a resident of i is $U_i(x_i)$ and her budget constraint is $(1 + t_i^x)x_i = (1 - t_i^\ell)w_i + y_i$. It follows that the indirect utility is:

$$V_i = U_i\left(\frac{1}{1 + t_i^x}[(1 - t_i^\ell)w_i + y_i]\right), \qquad \text{with } y_i = (1 - t_i^\pi)\theta_i^i m_i \pi_i + (1 - t_j^\pi)\theta_i^j m_j \pi_j.$$

The firm chooses its labor supply l_i so as to maximize its profit:

$$\pi_i = f_i(l_i, z_i, z_j) - w_i l_i.$$

Recall that f_i is increasing with respect to all its arguments and concave with respect to the firm's labor use l_i. Firm mobility implies that net profits are equated across jurisdictions:

$$(1 - t_1^\pi)\pi_1 = (1 - t_2^\pi)\pi_2$$

The resource constraint of the number of firms is $m_1 + m_2 = M$ and the clearing condition of the labor market is $n_i = m_i l_i$. The general equilibrium of the model defines, in each jurisdiction $i = 1, 2$, the number of firms m_i, the wage w_i and the profit π as a function of the profit tax and the public input in 1, i.e. t_1^π and z_1.

C.2. Responses

Inserting into the labor market clearing condition into the firm's first-order condition, we obtain $\partial f_i(n_i/m_i, z_i, z_j)/\partial l_i = w_i$ which characterizes $w_i(m_i, z_i, z_j)$ that is, the local wage in i as a function of the level of public inputs provided in both jurisdictions. Differentiating, we obtain:

$$\frac{\partial w_i}{\partial m_i} = -\frac{l_i}{m_i}\frac{\partial^2 f_i}{\partial l_i^2} > 0, \qquad \frac{\partial w_i}{\partial z_i} = \frac{\partial^2 f_i}{\partial z_i l_i} > 0, \qquad \frac{\partial w_i}{\partial z_j} = \frac{\partial^2 f_i}{\partial z_j l_i} > 0. \tag{A.24}$$

The first condition indicates that if jurisdiction i attracts an additional firm, the local wage increases: given the fixed population, more firms means that each firm is ready to bid more to hire workers. The last two conditions in (A.24) show that the direct effects of public input provision on the local and external wage are positive because of the resulting increase in workers' productivity. Notice that in the absence of spillover effects, $\partial w_i/\partial z_j = 0$.

Inserting the above wage function into the profit function, we obtain $\pi_i(m_i, z_i, z_j) = f_i(l_i, z_i, z_j) - w_i(m_i, z_i, z_j)l_i$ and differentiating and using the envelop theorem, it follows that:

$$\frac{\partial \pi_i}{\partial m_i} = -\frac{\partial w_i}{\partial m_i}l_i < 0, \qquad \frac{\partial \pi_i}{\partial z_i} = \frac{\partial f_i}{\partial z_i} - \frac{\partial w_i}{\partial z_i}l_i > 0, \qquad \frac{\partial \pi_i}{\partial z_j} = \frac{\partial f_i}{\partial z_j} - \frac{\partial w_i}{\partial z_j}l_i > 0, \tag{A.25}$$

assuming that $\partial f_i/\partial z_j - l_i \partial^2 f_i/\partial z_j \partial l_i > 0$ for all j, that is, first-order effects dominate second-order effects.[53] The first condition in (A.25) indicates that attracting a new firm reduces local profit due to the increase in the local wage. The last two conditions in (A.25) indicate that the public input increases both the local and external profits because it allow firms to produce more. Again, notice that in the absence of spillover effects, $\partial \pi_i/\partial z_j = 0$. Using the firm population constraint $m_1 + m_2 = M$ to substitute m_1 into the equal profit condition, we obtain: $(1 - t_1^\pi)\pi_1(m_1, z_1) = (1 - t_2^\pi)\pi_2(M - m_1, z_2)$, which characterizes the general equilibrium level of firms in each jurisdiction $i = 1, 2$, denoted $m_i^\star \equiv m_i(t_1^\pi, z_1)$. Differentiating the equal profit condition, we obtain:

$$\frac{\partial m_i^\star}{\partial t_i^\pi} = \frac{\pi_i}{(1 - t_i^\pi)\dfrac{\partial \pi_i}{\partial m_i} + (1 - t_j^\pi)\dfrac{\partial \pi_j}{\partial m_j}} < 0, \quad \frac{\partial m_i^\star}{\partial z_i} = -\frac{(1 - t_i^\pi)\dfrac{\partial \pi_i}{\partial z_i} - (1 - t_j^\pi)\dfrac{\partial \pi_j}{\partial z_i}}{(1 - t_i^\pi)\dfrac{\partial \pi_i}{\partial m_i} + (1 - t_j^\pi)\dfrac{\partial \pi_j}{\partial m_j}} > 0, \tag{A.26}$$

where the second sign condition is obtained by making the reasonable assumption that $(1 -$

[53] This property is satisfied by most standard production functions, including the Cobb-Douglas function $f(l_i, z_i, z_j) = l_i^\alpha z_i^\beta z_j^\gamma$, $\alpha, \beta \in (0, 1)$ and the CES function $f(l_i, z_i, z_j) = (al_i^\rho + bz_i^\rho + cz_j^\rho)^\rho$, $\rho < 1$ and $a, b > 0$.

$t_i^\pi)\partial\pi_i/\partial z_i - (1-t_j^\pi)\partial\pi_j/\partial z_i > 0$, that is the local profit effect of public input provision dominates the spillover effect on external profits. Condition (A.26) indicates that, as expected, profit taxation repels firms out of the jurisdiction, while public input provision attracts firms in the jurisdiction. Using (A.24), (A.25) and (A.26), it follows that the general equilibrium local number of firms $m_i^\star$, wage $w_i^\star$ and profit $\pi_i^\star$ have the following responses with respect to profit taxation:

$$\frac{\partial m_i^\star}{\partial t_i^\pi} < 0, \qquad \frac{\partial w_i^\star}{\partial t_i^\pi} = \frac{\partial w_i}{\partial m_i}\frac{\partial m_i^\star}{\partial t_i^\pi} < 0, \qquad \frac{\partial \pi_i^\star}{\partial t_i^\pi} = \frac{\partial \pi_i}{\partial m_i}\frac{\partial m_i^\star}{\partial t_i^\pi} > 0, \tag{A.27}$$

that is, an increase in the profit tax entails outflows of firms from jurisdiction i, which exerts an upward pressure on the local wage and thus reduces the local profit of a firm. The responses of the local number of firms, wages, and profit with respect to public input are:[54]

$$\frac{\partial m_i^\star}{\partial z_i} > 0, \qquad \frac{\partial w_i^\star}{\partial z_i} = \underbrace{\frac{\partial w_i}{\partial m_i}\frac{\partial m_i^\star}{\partial z_i}}_{>0} + \underbrace{\frac{\partial w_i}{\partial z_i}}_{>0} > 0, \qquad \frac{\partial \pi_i^\star}{\partial z_i} = \underbrace{\frac{\partial \pi_i}{\partial m_i}\frac{\partial m_i^\star}{\partial z_i}}_{<0} + \underbrace{\frac{\partial \pi_i}{\partial z_i}}_{>0} > 0, \tag{A.28}$$

that is, public input provision allows the jurisdiction to attract new firms. The wage increases both due to the direct positive effect of public inputs on firms productivity and due to the attraction of new firms in the jurisdiction. The last condition in (A.28) shows that despite the increase in the wage, the local profit increases due to the direct effect of public inputs on firms' productivity.

The responses to profit taxation in i of the variables in jurisdiction $j \neq i$ are the symmetric opposite to the responses of the variables in i:

$$\frac{\partial m_j^\star}{\partial t_i^\pi} > 0 \qquad \frac{\partial w_j^\star}{\partial t_i^\pi} = \frac{\partial w_j}{\partial m_j}\frac{\partial m_j^\star}{\partial t_i^\pi} > 0 \qquad \frac{\partial \pi_j^\star}{\partial t_i^\pi} = \frac{\partial \pi_j}{\partial m_j}\frac{\partial m_j^\star}{\partial t_i^\pi} < 0, \tag{A.29}$$

which has the same interpretation as (A.29): profit taxation in i makes j more attractive to firms and thus increases the wage and reduces the profit in j. Finally, the responses in jurisdiction j to public input provision in i are:

$$\frac{\partial m_j^\star}{\partial z_i} < 0 \qquad \frac{\partial w_j^\star}{\partial z_i} = \underbrace{\frac{\partial w_j}{\partial m_j}\frac{\partial m_j^\star}{\partial z_i}}_{<0} + \underbrace{\frac{\partial w_j}{\partial z_i}}_{>0} \qquad \frac{\partial \pi_j^\star}{\partial z_i} = \underbrace{\frac{\partial \pi_j}{\partial m_j}\frac{\partial m_j^\star}{\partial z_i}}_{>0} + \underbrace{\frac{\partial \pi_j}{\partial z_i}}_{>0} > 0, \tag{A.30}$$

[54] Notice that:

$$\frac{\mathrm{d}\pi_i}{\mathrm{d}z_i} = \frac{\partial \pi_i}{\partial z_i} + \frac{\partial \pi_i}{\partial m_i}\frac{\partial m_i}{\partial z_i} = (1-\xi_{ij})\frac{\partial \pi_i}{\partial z_i} + \xi_{ij}\frac{\partial \pi_j}{\partial z_i} > 0$$

where $\xi_{ij} \equiv (1-t_i^\pi)\partial\pi_i/\partial m_i / \left((1-t_i^\pi)\partial\pi_i/\partial m_i + (1-t_j^\pi)\partial\pi_j/\partial m_j\right) \in [0,1]$.

which states that by attracting j's firm, jurisdiction i induces an ambiguous effect on j's wage. Spillovers imply a direct positive effect on the wage, but the loss of firms reduces the wage. It can be shown that $\mathrm{d}w_j/\mathrm{d}z_i$ is positive if and only if the positive spillover effects, $\partial f_j/\partial z_i$ and $\partial^2 f_j/\partial z_i \partial l_j$, are strong enough.[55] The last condition in (A.30) indicates that the profit in j increases for two reasons: (1) public inputs directly increase profit because of production gains and (2) the firm outflight reduces local business competition. Table A.4 summarizes the signs of the responses to policy changes derived in (A.27)–(A.30) and reports the implications for the components of the MVPFs.

C.3. Local MVPFs

The expression of the MVPF in j of a policy change in i is, for $\tau_i \in \{t_i^\pi, z_i\}$ is:

$$MVPF_{\tau_i}^j = \frac{\text{IE}_{\tau_i}^j}{\text{ME}_{\tau_i}^j + \text{BE}_{\tau_i}^j + \text{PE}_{\tau_i}^j + \pi\text{E}_{\tau_i}^j + \text{FME}_{\tau_i}^j} \tag{A.31}$$

where the disposable income effect $\text{IE}_{\tau_i}^j$, the behavioral effect $\text{BE}_{\tau_i}^j$, the price effect $\text{PE}_{\tau_i}^j$, the profit effect $\pi\text{E}_{\tau_i}^j$ and the mobility effect $\text{FME}_{\tau_i}^j$ are as defined in Table A.4. The direct effects, mechanical and profit effects are as defined in (39) and (40). The definitions and signs of all the effects presents in the MVPF (A.31) are summarized in Table A.4. The table allows to gain intuition about the expected levels of the local and social MVPFs.

Let us first consider an increase in the profit tax t_i^π. The signs of the components of the local and external MVPFs are reported in columns 1 and 2 in Table A.4, respectively. Specifically, the local MVPF, can be written as:

$$MVPF_{\tau_i}^i = \frac{\overbrace{\text{IE}_{\tau_i}^i}^{<0}}{\underbrace{\text{ME}_{\tau_i}^i}_{<0} + \underbrace{\text{BE}_{\tau_i}^i}_{>0} + \underbrace{\underbrace{\text{PE}_{\tau_i}^i}_{>0} + \underbrace{\pi\text{E}_{\tau_i}^i}_{<0}}_{>0} + \underbrace{\text{FME}_{\tau_i}^i}_{>0}}, \tag{A.32}$$

where the price effect is assumed to dominate the profit effect. The numerator of the local MVPF

[55] Proof:

$$\text{sign}\left(\frac{\mathrm{d}w_j}{\mathrm{d}z_i}\right) = \text{sign}\left[-l_j m_i (1-t_i)\left(\frac{\partial f_i}{\partial z_i} - l_i \frac{\partial^2 f_i}{\partial z_i \partial l_i}\right)\left|\frac{\partial^2 f_j}{\partial l_j^2}\right| + l_j m_i (1-t_j)\frac{\partial f_j}{\partial z_i}\left|\frac{\partial^2 f_j}{\partial^2 l_j}\right| + l_i^2 m_j (1-t_i)\frac{\partial^2 f_j}{\partial z_i \partial l_j}\left|\frac{\partial^2 f_i}{\partial^2 l_i}\right|\right]$$

(A.32) indicates that the residents of i are willing to receive compensation for an increase in the profit tax, because as firms leave the jurisdiction, the residents' wage decrease.

The denominator confirms that the mechanical effect of the tax on the government's budget is to reduce the budget deficit. It also shows that the reduction in wage due to firms' outflight spurs households to reduce their private consumption, which results in a budgetary costly behavioral effect. The wage cut also entails a loss in labor tax revenues (price effect), which is also budgetary costly. However, the wage cut increases the firm's profit so extra revenues from profit taxation partly compensate the loss in labor tax revenues. Finally, the positive firm mobility effect indicates that the outflow of firms is also costly in terms of tax revenues for the jurisdiction.

Let us now turn to the MVPFs of public input provision. The signs of the components of the local MVPF are as in column 3 Table A.4, so we can write:[56]

$$MVPF^i_{z_i} = \frac{\overbrace{\mathrm{IE}^i_{z_i}}^{>0}}{\underbrace{\mathrm{ME}^i_{z_i}}_{>0} + \underbrace{\mathrm{BE}^i_{z_i}}_{<0} + \underbrace{\mathrm{PE}^i_{z_i}}_{<0} + \underbrace{\pi\mathrm{E}^i_{z_i}}_{<0} + \underbrace{\mathrm{FME}^i_{z_i}}_{<0}} \tag{A.33}$$

The numerator of expression (A.33) indicates that the residents are willing to pay for their government to provide more public inputs because public inputs increase the local wage not only directly by increasing firms' productivity but also indirectly by attracting new firms. This wage increase results in an increase in the residents' disposable income.

The denominator of (A.33) indicates that, as usual, public input provision is mechanically costly. However, it also entails four different budgetary gains for the government. First, the wage increase spurs individuals to increase their consumption and pay more commodity taxes. Second, the wage increase directly results in more labor tax revenues. Third, similarly, the profit increase increases the profit tax revenues. Finally, by attracting more firms, the jurisdiction benefits from additional tax revenues due to a scale effect. In sum, the denominator of (A.33) shows that the firms' mobility is budgetary beneficial in the case of extra public input provision.

[56] Notice that the closed-economy MVPF ignoring mobility under estimates the local MVPF in (A.33).

D. Additional tables

Table A.1. Paper notation

Description	Notation	Definition
		I. Effects in the MVPFs
		A. Numerator
Direct effect	$\text{DE}^j_{\tau_i}$	eq. (12)
Disposable income effect	$\text{IE}^j_{\tau_i}$	$(1-t^\ell_j)L_j\dfrac{\partial w_j}{\partial \tau_i} - (1+t^h_j)H_j\dfrac{\partial p_j}{\partial \tau_i}$
Ownership effect	$\text{OE}^j_{\tau_i}$	eq. (14)
		B. Denominator
Mechanical effect	$\text{ME}^j_{\tau_i}$	eq. (17)
Behavioral effect	$\text{BE}^j_{\tau_i}$	$-n_j\mathbf{t}_j\mathbf{q}_j\dfrac{\partial \mathbf{x}_j}{\partial \tau_i}$
Price effect	$\text{PE}^j_{\tau_i}$	$-n_j\mathbf{t}_j\mathbf{x}_j\dfrac{\partial \mathbf{q}_j}{\partial \tau_i}$
Profit effect	$\pi\text{E}^j_{\tau_i}$	$-m_j t^\pi_j\dfrac{\partial \pi_j}{\partial \tau_i}$
Household mobility effect	$\text{HME}^j_{\tau_i}$	$\dfrac{\partial c_j}{\partial \mathbf{n}}\dfrac{\partial \mathbf{n}}{\partial \tau_i} - r_j\dfrac{\partial n_j}{\partial \tau_i}$
Firm mobility effect	$\text{FME}^j_{\tau_i}$	$\dfrac{\partial c_j}{\partial \mathbf{m}}\dfrac{\partial \mathbf{m}}{\partial \tau_i} - t^\pi_j\pi_j\dfrac{\partial m_j}{\partial \tau_i}$
		II. Vectors
Local household tax vector	$\mathbf{t}_i$	$(t^\ell_i \quad t^h_i \quad t^x_i \quad t^n_i)$
Local price vector	$\mathbf{q}_i$	$(w_i \quad p_i \quad 1 \quad 1)$
Local consumption vector	$\mathbf{x}_i$	$(\ell_i \quad h_i \quad x_i \quad 1)$
Aggregate vector of local populations	$\mathbf{n}$	$(n_1 \dots n_I)$
Aggregate vector of local firm numbers	$\mathbf{m}$	$(m_1 \dots m_I)$
Aggregate policy instrument set	$\mathbf{P}$	$(P_1 \dots P_I)$
		III. Others
Local policy instrument set	P_i	$\{t^x_i, t^\ell_i, t^h_i, t^n_i, t^\pi_i, g_i, z_i\}$
Local household tax paid per resident	r_i	$t^\ell_i w_i\ell_i + t^h_i p_i h_i + t^x_i x_i + t^n_i$

Table A.2. Signs of the components of the MVPF, household policies.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		I. Responses							
		Tax ($\tau_i = t_i^b$)				Public good ($\tau_i = g_i$)			
	Response in $j = i$ or $j \neq i$	$j = i$		$j \neq i$		$j = i$		$j \neq i$	
	Agglomeration economies	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Population	$\frac{\partial n_j}{\partial \tau_i}$	−	−	+	+	+	+	−	−
Wage	$\frac{\partial w_j}{\partial \tau_i}$	+	−	−	+	−	+	+	−
Rent	$\frac{\partial p_j}{\partial \tau_i}$	−	−	+	+	+	+	−	−
Consumption	$\frac{\partial x_j}{\partial \tau_i}$	−	−	−	+	−	+	+	−
		II. MVPF							
		Tax ($\tau_i = t_i^b$)				Public good ($\tau_i = g_i$)			
	Local or External MVPF	$MVPF^i_{t_i^b}$		$MVPF^{j\neq i}_{t_i^b}$		$MVPF^i_{g_i}$		$MVPF^{j\neq i}_{g_i}$	
	Agglomeration economies	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
A. Numerator (WTP)									
$\text{DE}^j_{\tau_i}$	eq. (29a)	−	−	0	0	+	+	+	+
$\text{IE}^j_{\tau_i}$	$n_j\left((1-t_j^\ell)n_j\frac{\partial w_j}{\partial \tau_i} - (1+t_j^h)n_j\frac{\partial p_j}{\partial \tau_i}\right)$	+	−	−	+	−	+	+	−
B. Denominator (G)									
ME_{ij}	eq. (29a)	−	−	0	0	+	+	0	0
$\text{BE}^j_{\tau_i}$	$-n_j t_j^x \frac{\partial x_j}{\partial \tau_i}$	+	+	+	−	+	−	−	+
$\text{PE}^j_{\tau_i}$	$-n_j\left(t_j^h\frac{\partial p_j}{\partial \tau_i} + t_j^\ell\frac{\partial w_j}{\partial \tau_i}\right)$	−	+	+	−	+	−	−	+
$\text{HME}^j_{\tau_i}$	$\left(\frac{\partial c_j}{\partial n_j} - r_j\right)\frac{\partial n_j}{\partial \tau_i}$	−	+	+	−	+	−	−	+

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

Table A.3. MVPF comparisons.

		(1)	(2)	(3)	(4)
		Tax ($\tau_i = t_i^b$)		Public good ($\tau_i = g_i$)	
	Agglomeration economies	LOW	HIGH	LOW	HIGH
Closed-economy vs Local MVPF	$MVPF^{ci}_{\tau_i} - MVPF^i_{\tau_i}$	−	+	+	−
Social MVPF vs Local	$SMVPF_{\tau_i} - MVPF^i_{\tau_i}$	−	+	+	−

Table A.4. Signs of the components of the MVPF, business policies.

		(1)	(2)	(3)	(4)	(5)
		I. Responses				
		Profit tax ($\tau_i = t_i^\pi$)		Public input ($\tau_i = z_i$)		
	Response in $j = i$ or $j \neq i$	$j = i$	$j \neq i$	$j = i$	$j \neq i$	
	Public service spillovers	ANY	ANY	ANY	LOW	HIGH
Number of firms	$\frac{\partial m_j}{\partial \tau_i}$	$-$	$+$	$+$	$-$	$-$
Wage	$\frac{\partial w_j}{\partial \tau_i}$	$-$	$+$	$+$	$-$	$+$
Profit	$\frac{\partial \pi_j}{\partial \tau_i}$	$+$	$-$	$+$	$+$	$+$
Consumption	$\frac{\partial x_j}{\partial \tau_i}$	$-$	$+$	$+$	$-$	$+$
		II. MVPF				
		Profit tax ($\tau_i = t_i^\pi$)		Public input ($\tau_i = z_i$)		
	Local or External MVPF	$MVPF^i_{t_i^\pi}$	$MVPF^{j\neq i}_{t_i^\pi}$	$MVPF^i_{z_i}$	$MVPF^{j\neq i}_{z_i}$	
	Public service spillovers	ANY	ANY	ANY	LOW	HIGH
A. Numerator (WTP)						
$\text{IE}^j_{\tau_i}$	$n_j \frac{\partial w_j}{\partial \tau_i}$	$-$	$+$	$+$	$-$	$+$
B. Denominator (G)						
$\text{ME}^j_{\tau_i}$	eq. (39)	$-$	0	$+$	0	0
$\text{BE}^j_{\tau_i}$	$-t^x_j n_j \frac{\partial x_j}{\partial \tau_i}$	$+$	$-$	$-$	$+$	$-$
$\text{PE}^j_{\tau_i}$	$-t^\ell_j n_j \frac{\partial w_j}{\partial \tau_i}$	$+$	$-$	$-$	$+$	$-$
$\pi\text{E}^j_{\tau_i}$	$-t^\pi_j m_j \frac{\partial \pi_j}{\partial \tau_i}$	$-$	$+$	$-$	$-$	$-$
$\text{FME}^j_{\tau_i}$	$-\left(t^\pi_j \pi_j - \frac{\partial c_j}{\partial m_j}\right) \frac{\partial m_j}{\partial \tau_i}$	$+$	$-$	$-$	$+$	$+$

NOTE— The signs of the mobility effect $\text{FME}^j_{\tau_i}$ assume that tax revenues collected from a firm are larger than the cost it induces, i.e. $t^\pi_j \pi_j > \partial c_j / \partial m_j$. For public service spillovers, LOW [HIGH] means that for $j \neq i$, $\partial f_j / \partial z_i$ and $\partial^2 f_j / \partial z_i \partial l_j$ are sufficiently low [high] for $\partial w_j / \partial z_i$ to be positive [negative] according to footnote 55.