The Marginal Value of Public Funds as a Measure of Welfare in an Open Economy

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Abstract

Our objective is to establish and provide a framework for quantifying and calculating the welfare effects of fiscal policies in an open economy, with an emphasis on state and local governments in a federalist system. We do so by developing a model of fiscal policy when there are spillovers in tax bases and expenditures among competing local jurisdictions. We then derive how open economy considerations influence the marginal value of public funds (Hendren 2016). We provide guidance on the additional empirical components of the marginal value of public funds necessary to understand the welfare effects of taxes in federalist system.

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1 Introduction

The "credibility revolution" has had profound effects on empirical analysis in economics and, in particular, the interpretation and understanding of the effects of policy interventions on numerous economic measures. These causal estimates are useful to determining the welfare effects of policies, but economists have struggled to use them for welfare explanations. Hendren (2016) derives and Finkelstein and Hendren (2020) summarize how the marginal value of public funds (MVPF) – the ratio of the marginal benefit of a policy to the net marginal cost to the government of the policy – is a useful and transparent framework to map causal effects to welfare analysis. Critically, the net marginal cost is inclusive of how behavioral responses impact the government budget. Hendren and Sprung-Keyser (2020) then applies the MVPF to study 133 policy changes in the United States, calculating the MVPF, using empirical estimates in the literature.

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 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 and even national governments set policy in an open economy setting where tax/expenditure bases along with information are mobile across jurisdictions, where fiscal policies of one jurisdiction have spillover benefits on residents of other jurisdictions, and where jurisdictions compete and possibly interact strategically with each other (Agrawal et al., 2020). These open economy forces alter how we think about optimal policy and the welfare consequences of policy. Of course, these open economy concerns have been addressed in models dating back to Tiebout (1956), but recently, a large literature has now emerged showing the importance of mobility (Kleven et al., 2020), the effect of spillovers across jurisdictional borders (Case et al., 1993), spatial misaloccation resulting from taxation (Suárez Serrato and Zidar, 2016; Fajgelbaum et al., 2019) and fiscal competition (Brueckner, 2003).[1] But this literature has struggled to draw welfare implications of these competetive open economy forces. Thus, important questions relating to the welfare effects of fiscal competition remain unanswered.

[1]While the empirical literature on fiscal spillovers and tax competition is at least twenty- five years old with early studies including Besley and Case (1995) and Brueckner and Saavedra (2001) that generally employed spatial-lag models to estimate "tax reactions," that is, how one jurisdiction (nation, state, city) responds to tax policy changes in another jurisdiction, more recently, numerous studies have identification strategies to obtain causal estimates of these tax reactions. Examples of these studies include Agrawal (2015); Eugster and Parchet (2019); Parchet (2019); and Lyytikäinen (2012).

Our objective in this paper is to establish and provide a framework for quantifying and calculating the welfare effects of fiscal policy — both taxes and spending — in an open economy in which there are spillovers from fiscal policy and competitive forces from other jurisdictions. This framework, outlined in the following sections, applies the concept of MVPF into a general model of fiscal federalism and then use causal estimates of tax spillovers and tax reactions to obtain a measure of the MVPF following Hendren and Sprung-Keyser (2020). Critically, our MVPF nests the closed economy case, generalizing the applicability of the MVPF for many open economy considerations.

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

In an open economy, the functional form of the MVPF remains the same, but measuring the willingness to pay and the marginal cost become more nuanced. First, the mobility of taxpayers across jurisdictional school boundaries implies a policy change in one jurisdiction imposes an interjurisdictional fiscal externality on competitor jurisdictions. For example, a tax increase in Massachusetts may result in mobility toward Connecticut, raising tax revenue in Connecticut. Second, this mobility can result in the policies of one jurisdiction affecting equilibrium wages and rents via capitalization. Third, and likely the case for many municipal public services, spending in one jurisdiction may induce positive spillover benefits on other individuals. Parks may benefit nonresidents and education programs may increase the productivity of nonresidents. Finally, jurisdictions may strategically react to the policy reforms of other jurisdictions: a tax decrease in Massachussets may also trigger a tax decrease in Connecticut and these reactions may affect the willingness to pay and marginal cost of a policy.

Given we derive our MVPF in a spatial general equilibirum model, the willingness to pay and the marginal cost become more nuanced. In an open economy, 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, as in a Rosen-Roback framework.

With respect to the denominator of the MVPF, our model features the same two effects as in Hendren (2016) : the direct (mechanical) effect of the policy on the budget deficit, holding behavioral responses constant and a behavioral effect resulting from how the policy changes individual behavior, thus affecting the government budget. In addition, open economy concerns imply that there are two novel channels by which the marginal cost is affected by the policy. First, the policy change results in mobility. In case of a tax increase, for example, this results in a flow of individuals out of the jurisdiction. This alters the fiscal bases and revenues of the jurisdiction. Second, that mobility alters wages and land rents across jurisdictions to restore spatial equilibrium and the higher wages and rents results in increases in tax revenue in the jurisdiction. In small open economies, 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 MVPF.

We proceed by driving formal expressions for the MVPF for the same tax and spending instruments considered in Hendren (2016). In this context, we are able to show that when people are immobile, then wages and housing rents are constant, and the MVPF reduces to that in Hendren (2016). Obviously, mobility complicates the number of parameters necessary to calculate the MVPF. In addition to the information needed in Hendren and Sprung-Keyser (2020), the researcher needs to know the mobility elasticity as well as measures of capitalization, but these are all parameters that are often estimated in the local public finance literature, especially for local tax policy and local education spending.

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

Sprung-Keyser (2020) shows have an infinite marginal costs of public funds. The MVPF is negative if the program pays for itself — the marginal cost is negative. In our spatial general equilibirum model, an increase in education spending attracts individauls to this community, raising tax revenue in the jurisdiction. This increase in individuals raises house prices in the jurisdiction and raises wages if there are constant returns to scale. With respect to the numerator, the direct effect is the same as Hendren and Sprung-Keyser (2020), but the effect on income that manifests via changes in wages or rents, may raise or lower the willingness to pay.

In addition to the MVPF of a policy in one's own jurisdiction, we also derive other MVPF concepts. Because the benefits of public services spillover across jurisdictions and because tax changes impose fiscal externalities on nearby jurisdictions, a policy change in one jurisdiction has a "local" MVPF in other jurisdictions. Intuitively, consider the example of education provided in jurisdiction i. Nonresidents may benefit from education in nearby jurisdictions and thus have a positive willinness to pay for the other jurisdiction providing education, making the MVPF of jurisdiction j's MVPF for i's spending on parks nonzero. At the same time, increases in i's spending on education increases migration to the jurisdiction, which implies budgetary impacts on jurisdiction j's budget. Critically, if these spillovers are global in nature (environmental protection of airborn global pollutants), then these spillovers to any one other jurisdiction may be negligible. But, if these spillovers are local in nature (public roads), then these cross-jurisdiction effects influence a small number of jurisdictions, each in a potentially large way.

Given these spillover effects, we then consider the MVPF of a federal planner that accounts for hese spillovers. Critically, the federal planner's MVPF is the separate aggregation of the numerators and denominators of the local MVPFs. 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 marginal cost is the mechanical effect plus the own-jurisdiction fiscal externality plus the fiscal externality imposed on all other jurisdictions.

1.1 Background on the MVPF

Although recently popularized in several papers by Hendren, the MVPF has a long history. Understanding the welfare costs of public policies often follows the marginal excess burden approach adopted by Harberger (1964). Many economists have constructed various measures of non-budget neutral policies including marginal excess burden and marginal costs of public funds (Stiglitz and

Dasgupta, 1971; Atkinson and Stern, 1974; Auerbach, 1985; Fullerton, 1991; Auerbach and Hines Jr, 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

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

or alternatively,

$$MVPF = \frac{W}{1 + FE}, \quad (2)$$

where W is the willingness to pay (from their own income) of inframarginal recipients for each dollar of the program. And where FE is the fiscal externality – or the cost on the government budget – per dollar increase in the mechanical expenditures per inframarginal beneficiaries. Of course, these definitions can also apply to taxes rather than government expenditures. https://www.overleaf.com/project/60e5d4629c00500a8be6b0e7 Note that if the denominator of the MVPF is negative, the program is said to "pay for itself." An example would be a tax cut that increases government revenue. In this case the MVPF is negative, but Hendren and Sprung-Keyser (2020) define this as having an infinite MVPF, to make it clear the programs are "better" than programs with finite but positive MVPFs. Then, to compare the welfare effects of different policies, we can assume the all beneficiaries of a given (targeted) policy have the same social marginal utility of income. Then if η_i is the social marginal utility of policy i, a change in spending on policy 1 that is financed by policy 2 will increase welfare if

$$\eta_1 MVPF_1 \geq \eta_2 MVPF_2. \quad (3)$$

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

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

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

2 Model

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

2.1 Household

The economy consists of M jurisdictions indexed by $i = 1, \ldots, m$ with population n_i. Single-individual households are mobile across jurisdictions. The world economy includes N households who only differ with respect to their taste for jurisdiction i, denoted e_i. Each resident of jurisdiction i inelastically supplies one unit of labor in i receiving wage w_i and inelastically demands one unit of housing paying the rent p_i. The assumptions of inelastic labor supply and housing are innocuous and can easily be added to the model.

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

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

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

We proceed by considering that governments raise revenue from the same three taxes considered in Hendren (2016): a commodity tax, an income tax, and a head tax (alternatively, cash transfer). Of course, local governments (in the United State) also raise revenue from property taxes, and these taxes can easily be incorporated into the model. Then, the household budget constraint is:

$$p_i + (1 + t_i^x)x_i = y_i + (1 - t_i^l)w_i - t_i^n \tag{5}$$

where y_i is non-labor income, t_i^x is an ad valorem commodity tax, t_i^l is an ad valorem labor tax and t_i^n is a head tax, which also acts as a possible government expenditure via a cash transfer. We assume absentee landlords and capital owners. Rewriting the budget constraint, (5), make explicit how consumption depends on prices and taxes:

$$x_i = \frac{1}{1 + t_i^x}\left[y_i + (1 - t_i^l)w_i - p_i - t_i^n\right]. \tag{6}$$

Plugging the expression for x_i given by (6) into the utility function given by (4), we obtain the indirect utility function:

$$V_i + e_i = U\left(\frac{1}{1 + t_i^x}[y_i + (1 - t_i^l)w_i - t_i^n - p_i], g_i, \mathbf{g}_{-i}\right) + e_i, \tag{7}$$

from which it follows that the marginal utility of income is:

$$\lambda_i \equiv \frac{\partial V_i}{\partial y_i} = \frac{1}{1 + t_i^x}\frac{\partial U_i}{\partial x_i}, \tag{8}$$

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

$$\Delta_i = cg_i - n_i(t_i^l w_i + t_i^x x_i + t_i^n) \tag{9}$$

where c is the marginal cost of providing the pure public good. For notational simplicity, the budget deficit can alo be written as:

$$\Delta_i = cg_i - n_i \sum_{z=l,x,n} t_i^z b_i^z = cg_i - n_i r_i \tag{10}$$

where z indexes each base:

$$b_i^l = w_i \qquad b_i^x = x_i \qquad b_i^n = 1. \tag{11}$$

are the per capita tax bases and:

$$r_i = \sum_{z=l,x,n} t_i^z b_i^z \tag{12}$$

is the per capita tax revenue.

2.2 Location choice

In our model, we will focus on household mobility, which has been argued to be critical at the state and local level. In particular, a large literature shows that individuals are mobile in response to taxes (Kleven et al., 2020), welfare programs (Brueckner, 2000; Agersnap et al., 2020), and education programs (Epple et al., 2014). In our model, each jurisdiction is endowed with a single immobile firm which uses inter-jurisdictionally mobile capital. Wage incidence results from the degree of returns to scale under which firms operate (section 2.3) unlike Suárez Serrato and Zidar (2016) in which it results from the locations of heterogeneous firms.

In line with e.g. Schmidheiny and Slotwinski (2018), we model household mobility by assuming that e_i is i.i.d. according to the following Gumbel distribution:[2]

$$F(z) = P(e_i \leq z) = e^{-e^{-\left(\frac{z}{\mu}+\gamma\right)}} \tag{13}$$

[2] Alternatively, assuming that e_i follows a Fréchet distribution as in Ahlfeldt et al. (2015) would not alter our results.

where γ is the Euler's constant ($\gamma \approx 0.5772$) and μ is a positive constant which governs the variance of e_i which is equal to $\pi^2/(6\mu^2)$. The interpretation of parameter μ is provided below. Discrete choice theory allows to derive the probability that a household choose to reside in jurisdiction i:[3]

$$\pi_i \equiv P\left[V_i + e_i = \max_{j=1,\dots,m}(V_j + e_j)\right] = \frac{\exp(\mu V_i)}{\sum_{j=1}^{m}\exp(\mu V_j)} \tag{14}$$

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

$$n_i = \pi_i N = \frac{\exp(\mu V_i)}{\sum_{j=1}^{m}\exp(\mu V_j)} N \tag{15}$$

Notice that this expression guarantees that the population constraint holds:

$$\sum_{i=1}^{n} n_i = N \tag{16}$$

Parameter μ measures the degree of inter-jurisdictional mobility of the households. First, if $\mu \to 0$, equation (15) indicates that households are immobile and all jurisdictions are inhabited by N/m residents. Second, if $\mu \to \infty$, then the variance of the idiosyncratic parameter, e_i, goes to zero. All households are identical so that they all prefer to live in the jurisdiction which provides the highest level of utility. Household mobility is costless as in Roback (1982).

To see how utility changes affects the location of individuals, we can differentiate (15) with respect to the indirect utilities. We obtain:

$$\frac{\mathrm{d}n_i}{\mathrm{d}V_i} = \mu\frac{n_i(N-n_i)}{N} > 0, \qquad \frac{\mathrm{d}n_j}{\mathrm{d}V_i} = -\mu\frac{n_i n_j}{N} < 0, \qquad \forall j \neq i, \tag{17}$$

which indicates indicates that, as expected, an increase in utility in jurisdiction i induces a population flow from all other jurisdictions to jurisdiction i. The second derivative is usually termed the *gravity equation* as a reference to the trade literature (Krugman, 1980); it states that population flows across jurisdictions are governed by their bilateral population sizes.

Due to the one-unit individual housing demand, n_i is the aggregate housing demand in jurisdiction i. Differentiating (15) with respect to the housing rent, p_i, we obtain $\mathrm{d}n_i/\mathrm{d}p_i < 0$ and $\mathrm{d}n_j/\mathrm{d}p_i > 0$, $\forall j \neq i$. That is, an increase in the rent of jurisdiction i entails an outflows of residents from jurisdiction i and an inflows in other jurisdictions. Similarly, due to the one-unit individual labor supply and the absence of interjurisdictional commuting, n_i is also the aggregate labor supply in jurisdiction i, and: $\mathrm{d}n_i/\mathrm{d}w_i > 0$ and $\mathrm{d}n_j/\mathrm{d}w_i < 0$, $\forall j \neq i$. That is, an increase in its local wage allows jurisdiction i to attract residents-workers from other jurisdictions.

[3] This expression corresponds to equation (10) in Kline and Moretti (2014).

2.3 General equilibrium

The housing market equilibrium in jurisdiction i is:

$$n_i = H_i(p_i), \tag{18}$$

where $H_i(p_i)$ is the housing supply function in jurisdiction i, with $H_i'(p_i) > 0$. Condition (18) implicitly defines the housing rent p_i as a function of the population. Implicitly differentiating (18), we obtain:

$$\frac{\mathrm{d}p_i}{\mathrm{d}n_i} = \frac{1}{H_i'(p_i)} > 0, \tag{19}$$

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

The numéraire good is produced using labor n_i and capital k_i under constant returns to scale. The production technology is denoted $F_i = F_i(n_i, k_i)$ and exhibits positive but decreasing marginal returns with respect to each factor. Labor and capital are technological complements in production, i.e. $\partial^2 F_i/\partial n_i \partial k_i > 0$. Moreover, F_i is homogeneous of degree $\psi + 1$, $\psi \in \mathbb{R}$. This production technology includes three different economic cases. First, if $\psi > 0$, the technology exhibits internal increasing returns to scale, which captures agglomeration economies. [4] Second, if $\psi < 0$, the technology exhibits decreasing returns to scale. That is, doubling labor and capital inputs is not enough to double production. This might be due to the presence of a fixed factor such as land. Third, if $\psi = 0$, constant returns to scale prevail. This last case might occur if there is no agglomeration economies and if all factors can be considered either as labor or as capital. The firm's profit is

$$\Pi_i = F_i(n_i, k_i) - w_i n_i - \rho k_i, \tag{20}$$

where ρ the exogenous world capital return; capital is assumed to be perfectly elastically supplied to jurisdictions.

We assume that capital input is chosen competitively by the firm so as to maximize profit, (20), so that the usual first-order condition is obtained:

$$\frac{\partial F_i}{\partial k_i} = \rho \tag{21}$$

Due to possible increasing [decreasing] returns to scale, in the equilibrium, the firm can make positive profits [losses]. We assume that extra profit is assigned to workers. Then, the wage w_i is

[4] This modeling of agglomeration economies is similar to Burbidge and Cuff (2005).

characterized by the zero profit condition $\Pi_i = 0$ which is equivalent to:

$$w_i = \frac{F_i - \rho k_i}{n_i}. \tag{22}$$

Conditions (21) and (22) implicitly define the capital stock k_i and the wage w_i as a function of the number of workers n_i. Implicitly differentiating, we obtain:[5]

$$\frac{\mathrm{d}k_i}{\mathrm{d}n_i} = -\frac{\dfrac{\partial^2 F_i}{\partial n_i \partial k_i}}{\dfrac{\partial^2 F_i}{\partial k_i^2}} > 0, \tag{23}$$

and:

$$\frac{\mathrm{d}w_i}{\mathrm{d}n_i} = \psi \frac{F_i}{n_i^2} \quad \gtreqless 0 \quad \iff \psi \gtreqless 0. \tag{24}$$

Condition (23) indicates that firms demand more capital when the number of workers increases. This results from the complementarity of capital and labor. Condition (24) indicates that in the case of agglomeration economies [decreasing returns] to scale), i.e. $\psi > 0$ [$\psi < 0$], the larger the workforce, the higher [lower] the wage. If, however, constant returns to scale prevail ($\psi = 0$), the wage is constant.[6]

The $3M$ equilibrium conditions (15), (18) and (22) implicitly define the levels of the M populations $n_1, \ldots, n_M$, the M housing rents $p_1, \ldots, p_M$ and the M wages $w_1, \ldots, w_M$ as a function of the M policy instrument sets of the jurisdictions:

$$P_i = \left\{ t_i^x, t_i^l, t_i^n, g_i. \right\} \qquad i = 1, \ldots, M \tag{25}$$

Inserting the housing rent and wage equilibrium functions into the expression for consumption (6), it follows that the equilibrium local consumption levels x_i, $i = 1, \ldots, M$ is also a direct function of the policy instrument sets P_i, $i = 1, \ldots, M$. To highlight that in equilibrium, populations, rents, wages and consumptions in a jurisdiction depends on the policy settings in all jurisdictions, we express these equilibrium variables as $n_i(\mathbf{P})$, $p_i(\mathbf{P})$, $w_i(\mathbf{P})$ and $x_i(\mathbf{P})$, where

$$\mathbf{P} = (P_1, \ldots, P_M), \tag{26}$$

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

$$\mathbf{P}_{-i} = (P_1, \ldots, P_{i-1}, P_{i+1}, P_M), \tag{27}$$

[5] See Appendix A for a detailed proof.

[6] Constant returns to scale and thus constant wage are considered in Kline and Moretti (2014), for example.

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

2.4 Responses of the economy to policy changes

Having characterized the spatial general equilibrium, this section studies how populations and consumption respond to changes in the level of the policy instruments of a given jurisdiction. The purpose is to provide insights into the components of the MVPF that we will introduce in the next sections. In the fully flexible model introduced in the previous subsections, these responses are by nature ambiguous and depend on model specifications (e.g. different housing supply and production functions) and calibration. To gain intuition, this subsection (only) focuses a special case that guarantees meaningful economic responses and is intuitive. Namely, we consider an economy with $M = 2$ jurisdictions. We assume that for each $i = 1, 2$ and $j = 1, 2$ with $j \neq i$:[7]

$$(1 - t_i^l)\frac{\mathrm{d}w_i}{\mathrm{d}n_i} - \frac{\mathrm{d}p_i}{\mathrm{d}n_i} < \frac{N\,(1 + t_i^x)}{\mu n_i n_j \dfrac{\partial U_i}{\partial x_i}} \tag{28}$$

where $\mathrm{d}w_i/\mathrm{d}n_i$ and $\mathrm{d}p_i/\mathrm{d}n_i$ are as defined in (19) and (24). Assumption (28) 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 constant returns to scale ($\psi = 0$) or decreasing returns to scale ($\psi < 0$), we have $\mathrm{d}w_i/\mathrm{d}n_i \leq 0$ from (24), so that condition (28) immediately holds since rent is an increasing function of population and the right-hand side of (28) is strictly positive. Thus, this assumption is only necessary in the case of agglomeration economies.

Differentiating (15) with respect to policy instrument $\tau \in \mathbf{P}$, we obtain for each tax $z = n, x, l$ and spending policy:[8]

$$\frac{\partial n_i}{\partial t_i^z} < 0, \qquad \frac{\partial n_i}{\partial g_i} > 0. \tag{29}$$

As expected, conditions (29) state that an increase in local taxation entails outflows of residents, while an increase in public good provision attracts new residents. The signs of the housing rent and

[7] In the case of household perfect mobility ($\mu \to \infty$), condition (28) reduces to $(1 - t_i^l)\frac{\mathrm{d}w_i}{\mathrm{d}n_i} - \frac{\mathrm{d}p_i}{\mathrm{d}n_i} < 0$, which guarantees stability of the location equilibrium. In our model, stability is guaranteed by the idiosyncratic taste of individuals for locations, but condition (28) guarantees economically meaningful responses of population to policy changes.

[8] See Appendix B for detailed derivations.

wage responses follow from (19) and (24) and are, for the set of taxes and spending policies:

$$\frac{\partial p_i}{\partial t_i^z} < 0, \qquad \text{sign}\left(\frac{\partial w_i}{\partial t_i^z}\right) = -\text{sign}(\psi), \tag{30}$$

$$\frac{\partial p_i}{\partial g_i} > 0, \qquad \text{sign}\left(\frac{\partial w_i}{\partial g_i}\right) = \text{sign}(\psi), \tag{31}$$

For example, we know from (29) that a marginal increase in any tax entails outflows of residents. Condition (30) 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 agglomeration economies [decreasing returns to scale] $\psi > 0$ [$\psi < 0$], less population also means a lower [higher] wage.

Next, we turn to the responses of private consumption x_i to policy changes. To gain intuition, consider first the case of a marginal increase in the head tax t_i^n. Differentiating (6), we obtain:

$$\frac{\partial x_i}{\partial t_i^n} = \frac{1}{1+t_i^x}\left(-1 + (1-t_i^l)\frac{\partial w_i}{\partial t_i^n} - \frac{\partial p_i}{\partial t_i^n},\right) \tag{32}$$

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

$$\frac{\partial x_i}{\partial t_i^z} < 0, \qquad \text{sign}\left(\frac{\partial x_i}{\partial g_i}\right) = \text{sign}\left((1-t_i^l)\frac{\mathrm{d}w_i}{\mathrm{d}n_i} - \frac{\mathrm{d}p_i}{\mathrm{d}n_i}.\right) \tag{33}$$

The first conditions for the three taxing instruments in (33) indicate that the direct negative income effect of taxation always dominates the possibly positive disposable income effect resulting from mobility. The last condition in (33) states that because the public good g_i does not directly enter the equation for prive consumption, its effect only consists of an indirect effect via the housing rent and the wage. In particular, an increase in g_i attracts new residents, increases the rent, alters the wage and thus changes the disposable income. In the case of agglomeration economy and sufficient capitalization of household inflows into the wage, the disposable income increases which increases the local consumption. On the contrary, if the local wage moderately increases or even decreases ($\psi < 0$), following the entry of new residents in the jurisdiction, consumption decreases.

[9] See Appendix B for detailed derivations.

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

$$\text{sign}\left(\frac{\partial x_j}{\partial t_i^z}\right) = \text{sign}\left((1 - t_j^l)\frac{\mathrm{d}w_j}{\mathrm{d}n_j} - \frac{\mathrm{d}p_j}{\mathrm{d}n_j}\right), \tag{34}$$

$$\text{sign}\left(\frac{\partial x_j}{\partial g_i}\right) = -\text{sign}\left((1 - t_j^l)\frac{\mathrm{d}w_j}{\mathrm{d}n_j} - \frac{\mathrm{d}p_j}{\mathrm{d}n_j}\right). \tag{35}$$

All the above effects are indirect effects resulting from mobility that affect jurisdiction j through changes in its local rent p_j, its local wage w_j, changing its residents' disposable income and consumption. Condition (34) indicates that any increase in jurisdiction i's tax increases the attractiveness of jurisdiction j which increases its rent, alters its wage and thus its disposable income. Depending on the relative capitalization of this mobility into wages and rents, consumption can increase or decrease, as discussed above. The same applies to public good provision as can be seen in condition (35). However, the effect goes in the opposite direction as public good provision allows the jurisdiction changing the policy to attract residents rather than repel them as taxation does.

It can be shown that in the case of household immobility, i.e. $\mu \to 0$, for all $\tau_i \in \{t_i^n, t_i^n, t_i^n, g_i\}$ and $z = n, x, l$, we have for each $i = 1, 2$ and $j = 1, 2$ with $j \neq i$:

$$\frac{\partial n_i}{\partial \tau_i} \to 0 \qquad \frac{\partial x_i}{\partial t_i^z} < 0 \qquad \frac{\partial x_i}{\partial t_i^l} < 0 \qquad \frac{\partial x_i}{\partial t_i^x} < 0 \qquad \frac{\partial x_i}{\partial g_i} \to 0 \qquad \frac{\partial x_j}{\partial \tau_i} \to 0, \tag{36}$$

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 $\partial x_i/\partial t_i^z < 0$ and $\partial x_j/\partial t_i^z = 0$. Public good provision entails no direct effect on consumption so that $\partial x_i/\partial g_i \to 0$ and $\partial x_i/\partial g_j \to 0$.

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

3 Marginal Value of Public Funds (MVPF)

This section derives the MVPF in open economies with spillovers and mobility. Section 3.1 discusses how indirect utility and the budget deficit respond to policy changes. Section 3.2 introduces the notion of a policy path. Section 3.3 derives the expression of local MVPFs, that is, the MVPF facing a single jurisdiction. Section 3.4 derives the expressions of related social MVPFs, that is, the MVPF facing a federal planner.

3.1 Indirect utility and budget deficit

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

3.1.1 Indirect utility

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

$$V_i(\mathbf{P}) = U\left(\frac{1}{1+t_i^x}[(1-t_i^l)w_i(\mathbf{P}) - t_i^n - p_i(\mathbf{P})], g_i, \mathbf{g}_{-i}\right) \tag{37}$$

Differentiating (37), we obtain:

$$\frac{1}{\lambda_i}\frac{\partial V_i}{\partial t_i^z} = -b_i^z + (1-t_i^l)\frac{\partial w_i}{\partial t_i^z} - -\frac{\partial p_i}{\partial t_i^z}, \qquad \text{for } z = l, n, x \tag{38}$$

and:

$$\frac{1}{\lambda_i}\frac{\partial V_i}{\partial g_i} = \frac{1}{\lambda_i}\frac{\partial U_i}{\partial g_i} + (1-t_i^l)\frac{\partial w_i}{\partial g_i} - \frac{\partial p_i}{\partial g_i} \tag{39}$$

Condition (38) indicates that the effect of a marginal increase in the local tax t_i^z on indirect utility V_i of a resident includes two sub-effects, only the first of which is in Hendren (2016):[10]

1. **direct effect on willingness-to-pay**: $-b_i^z$ is a negative effect on willingness to pay from increasing t_i^z.

2. **mobility effect on willingness to pay**: $(1-t_i^l)\partial w_i/\partial t_i^z - \partial p_i/\partial t_i^z$ is an ambiguously signed effect on willingness to pay resulting from the impact of the tax on disposable income $(1 - t_i^l)w_i - p_i$ due to price (wage and housing rent) changes. This effect can be interpreted as the effect of household mobility on utility. It is not present in Hendren (2016), who assumes exogenous prices.

[10] The interpretation of condition (39) is similar to that of condition(38).

Differentiating the resident's indirect utility V_i with respect to another jurisdiction j's policy instruments, we obtain:

$$\frac{1}{\lambda_i}\frac{\partial V_i}{\partial t_j^z} = (1-t_i^l)\frac{\partial w_i}{\partial g_j} - \frac{\partial p_i}{\partial t_j^z}, \qquad \text{for} \quad z = l, n, x, \; j \neq i, \tag{40}$$

and:

$$\frac{1}{\lambda_i}\frac{\partial V_i}{\partial g_j} = \frac{\partial U_j}{\partial g_i} + (1-t_i^l)\frac{\partial w_i}{\partial g_j} - \frac{\partial p_i}{\partial g_j}. \tag{41}$$

The effect on the indirect utility V_i of all tax changes in another jurisdiction j reduces to the mobility effect. However, due to public good spillovers, a change in another jurisdiction public good provision also has a direct effect.

3.1.2 Budget deficit

We can denote the budget deficit (10) as follows:

$$\Delta_i(\mathbf{P}) = cg_i - n_i(\mathbf{P})\left[t_i^l w_i(\mathbf{P}) + t_i^x x_i(\mathbf{P}) + t_i^n\right]. \tag{42}$$

It follows that:

$$\frac{\partial \Delta_i}{\partial t_i^z} = -n_i b_i^z - n_i t_i^x \frac{\partial x_i}{\partial t_i^z} - n_i t_i^l \frac{\partial w_i}{\partial t_i^z} - r_i \frac{\partial n_i}{\partial t_i^z}, \qquad \text{for } z = l, n, x, \tag{43}$$

and:

$$\frac{\partial \Delta_i}{\partial g_i} = c - n_i t_i^x \frac{\partial x_i}{\partial g_i} - n_i t_i^l \frac{\partial w_i}{\partial g_i} - r_i \frac{\partial n_i}{\partial g_i}. \tag{44}$$

Condition (43) indicates that the effect on the budget deficit of a marginal increase in the tax t_i^z can be decomposed in four sub-effects. The first two sub-effects do not result from household mobility and are also present in Hendren (2016):[11]

1. **a mechanical effect**: $-n_i b_i^z$ is the negative effect of a tax increase on the budget deficit.

2. **a behavioral effect**: $-n_i t_i^x \partial x_i / \partial t_i^z$ is due to the effect of changes in t_i^z on the consumption x_i. This, in turn, alters the commodity tax revenues. If labor supply, or other activities were elastic, similar terms would appear for these behavioral responses if they affect the government budget.

[11] The interpretation of condition (44) is similar to that of condition (43).

The second set of sub-effects result from household mobility and from the subsequent price changes; they are not in Hendren (2016) which assumes immobile households:

1. **a mobility effect**: $-r_i \partial n_i / \partial t_i^z$ is due to the effect of changes in t_i^z on flows of households into [out of] jurisdiction i. This alters all the tax bases and revenues of that jurisdiction.

2. **a price (or wage) effect**: $-n_i t_i^l \partial w_i / \partial t_i^z$ is due to the effect of changes in t_i^z on the local wage. This alters the labor tax base and revenues. If our model featured a property tax, the effect of house price capitalization would also influence government revenues and would similarly appear in this term.

Finally, when other governments change their policies, these policy changes have spillover effects that impose fiscal externalities on jurisdiction i. The effect of other jurisdictions' policy instruments on jurisdiction j's budget is:

$$\frac{\partial \Delta_i}{\partial \tau_j} = -n_i t_i^x \frac{\partial x_i}{\partial \tau_j} - n_i t_i^l \frac{\partial w_i}{\partial \tau_j} - r_i \frac{\partial n_i}{\partial \tau_j}, \qquad \text{for all } \tau_j \in P_j, \ j \neq i. \tag{45}$$

These effects are zero in Hendren (2016) which considers a single closed jurisdiction.

3.2 Policy path

Following Hendren (2016), we consider a policy path representing a policy change in the level of the instruments in set P_i defined in (25). For parameter $\theta \in (-\varepsilon, \varepsilon)$ with ε close to zero 0, we define a policy path" as:

$$P_i(\theta) = \left\{ t_i^x(\theta), t_i^l(\theta), t_i^n(\theta), g_i(\theta) \right\} \tag{46}$$

where $t_i^x(\theta)$ is a consumption tax, $t_i^l(\theta)$ is a labor tax, $t_i^n(\theta)$ is a head tax, $g_i(\theta)$ is public good provision.[12] We normalize the value of the policy at $\theta = 0$ to be the status quo so that:

$$\left\{ t_i^x(0), t_i^l(0), t_i^n(0), g_i(0) \right\} \equiv \left\{ t_i^x, t_i^l, t_i^n, g_i \right\} \tag{47}$$

and we assume that the policy path $P_i(\theta)$ is continuously differentiable in θ. In the remainder of the paper, all the equilibrium values of each endogenous variable X is denoted $X(\theta)$.

The policy path traces out a continuous path of government policies, which is centered on the status quo. The policy path allows of to consider policies that vary multiple policy parameters at the same time. For example, an increase in road spending financed by an increase in the sales tax would be given by $\mathrm{d}\tau_i^x / d\theta > 0$ and $\mathrm{d}g_i / \mathrm{d}\theta > 0$.

[12] The policy instruments considered are similar to those in Hendren (2016).

3.3 Local MVPF

We next proceed by deriving the marginal value of public funds. Here we define the **"local"** marginal value of public funds as the MVPF for a policy change by a single jurisdiction i. Because individuals receive utility from the policies of other jurisdictions, a policy change in jurisdiction i may also affect the MVPF of other nearby jurisdictions. The former of these is the **own-MVPF**, while the latter is the **cross-MVPF**. In contrast to the local MVPF, the **"social"** MVPF is the marginal value of public funds for a federal planner that accounts for spillovers across jurisdictions.

3.3.1 General definition

In its most general form, the Local Marginal Value of Public Funds (LMVPF) in jurisdiction i is similar to the prior literature:[13]

$$LMVPF_i \equiv \frac{n_i V_i'(0)/\lambda_i}{\Delta_i'(0)} \qquad = \frac{\text{"Marginal benefit"}}{\text{"Marignal cost"}}. \tag{48}$$

In the context of our model we have

$$V_i(\theta) = U\left(\frac{1}{1+t_i^x(\theta)}\left[\big(1-t_i^l(\theta)\big)w_i(\theta) - t_i^n(\theta) - p_i(\theta)\right], g_i(\theta), \mathbf{g}_{-i}(\theta)\right) \tag{49}$$

is the deterministic part of the indirect utility function (7), and

$$\Delta_i(\theta) = cg_i(\theta) - n_i(\theta)\left[t_i^l(\theta)w_i(\theta) + t_i^x(\theta)x_i(\theta) + t_i^n(\theta)\right] \tag{50}$$

is the budget deficit (10). We can now proceed to see how each of the general parts of (48) are affected by mobility and spillovers and how these effects are missing from the prior literature.

3.3.2 Some local MVPFs

We are interested in marginal changes in the instruments $\tau \in P_i$. Then, we have that:

$$\frac{\partial \tau(\theta)}{\partial \theta} = 1, \qquad \text{and} \quad \frac{\partial \widehat{\tau}(\theta)}{\partial \theta} = 0, \quad \text{for all } \widehat{\tau} \in P_i, \text{ with } \widehat{\tau} \neq \tau, \tag{51}$$

Given the presence of spillovers, denote $LMVPF_i^\tau$ as the local MVPF for jurisdiction i following its own policy change and let $LMVPF_j^\tau$ be the cross-jurisdiction MVPF due to spillovers. Using the expressions derived in section 3.1, the own-effect local MVPFs with respect to tax instrument

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

t_i^z, $z = l, n, x$ are:

$$LMVPF_i^{t_i^z} = \frac{\dfrac{n_i}{\lambda_i}\dfrac{\partial V_i}{\partial t_i^z}}{\dfrac{\partial \Delta_i}{\partial t_i^z}} = \frac{-n_i b_i^z + n_i\left((1-t_i^l)\dfrac{\partial w_i}{\partial t_i^z} - \dfrac{\partial p_i}{\partial t_i^z}\right)}{-n_i b_i^z - n_i t_i^x \dfrac{\partial x_i}{\partial t_i^z} - n_i t_i^l \dfrac{\partial w_i}{\partial t_i^z} - r_i \dfrac{\partial n_i}{\partial t_i^z}}, \tag{52}$$

The own-effect local MVPFs with respect to public good provision g_i is:

$$LMVPF_i^{g_i} = \frac{\dfrac{n_i}{\lambda_i}\dfrac{\partial V_i}{\partial g_i}}{\dfrac{\partial \Delta_i}{\partial g_i}} = \frac{\dfrac{n_i}{\lambda_i}\dfrac{\partial U_i}{\partial g_i} + n_i\left((1-t_i^l)\dfrac{\partial w_i}{\partial g_i} - \dfrac{\partial p_i}{\partial g_i}\right)}{c - n_i t_i^x \dfrac{\partial x_i}{\partial g_i} - n_i t_i^l \dfrac{\partial w_i}{\partial g_i} - r_i \dfrac{\partial n_i}{\partial g_i}}. \tag{53}$$

Recall that $\lambda_i = (1/(1+t_i)) \times \partial U_i/\partial x_i$ from (8).

In the extreme case where population is immobile, wages and housing rents are constant. Indeed, as seen in section 2.3, wage and rent depend on policy instruments only via the population. This can be stressed by denoting $w_i(n_i(\tau))$ and $p_i(n_i(\tau))$. Differentiating we obtain:

$$\frac{\partial n_i}{\partial \tau} = 0 \Rightarrow \begin{cases} \dfrac{\partial w_i}{\partial \tau} = 0 \\ \dfrac{\partial p_i}{\partial \tau} = 0. \end{cases} \qquad \tau \in P_i \tag{54}$$

In the case of immobile populations, the above MVPFs (52) are (53) are identical to those in Hendren (2016). For example, assuming that condition (54) holds, the LMVPF for the marginal head tax increase (52) becomes:

$$LMVPF_i^{t_i^n} = \frac{1}{1 + t_i^x \dfrac{\partial x_i}{\partial t_i^n}}. \tag{55}$$

In other words, the MVPF is one over the mechanical effect plus the behavioral effect – or one over one plus the fiscal externality.

As noted previously, policy change in any one jurisdiction will have budgetary effects in other jurisdictions. Moreover, because of the presence of expenditure spillovers, individuals in other jurisdictions will have a positive willingness to pay for increases in public services elsewhere. This leads to cross-jurisdiction MVPFs. Using the expressions derived in section 3.1, we have the following cross-effect local MVPFs:

$$LMVPF_j^{t_i^z} = \frac{\dfrac{n_j}{\lambda_j}\dfrac{\partial V_j}{\partial t_i^z}}{\dfrac{\partial \Delta_j}{\partial t_i^z}} = \frac{n_j\left((1-t_j^l)\dfrac{\partial w_j}{\partial t_i^z} - \dfrac{\partial p_j}{\partial t_i^z}\right)}{-n_j t_j^x \dfrac{\partial x_j}{\partial t_i^z} - n_j t_j^l \dfrac{\partial w_j}{\partial t_i^z} - r_j \dfrac{\partial n_j}{\partial t_i^z}}, \qquad \text{for } z = l, n, x, \tag{56}$$

and:

$$LMVPF_j^{g_i} = \frac{\dfrac{n_j}{\lambda_j}\dfrac{\partial V_j}{\partial g_i}}{\dfrac{\partial \Delta_j}{\partial g_i}} = \frac{\dfrac{n_j}{\lambda_j}\dfrac{\partial U_j}{\partial g_i} + n_j\left((1-t_j^l)\dfrac{\partial w_j}{\partial g_i} - \dfrac{\partial p_j}{\partial g_i}\right)}{-n_j t_j^x \dfrac{\partial x_j}{\partial g_i} - n_j t_j^l \dfrac{\partial w_j}{\partial g_i} - r_j \dfrac{\partial n_j}{\partial g_i}} \tag{57}$$

In Hendren (2016), these two cross-effect MVPFs are ignored. We see that in the case of immobile population so that (54) holds, only $LMVPF_j^{t_i^z}$ is zero; $LMVPF_j^{g_i} \neq 0$ due to public good spillovers of g_i in other jurisdictions. Only if $U_i = U(x_i, g_i) + e_i$ would $LMVPF_j^{g_i}$ be zero.

3.3.3 The importance of mobility in estimating the MVPF

Why does accounting for inter-jurisdictional mobility matter in assessing a public policy when using the MVPF as an indicator? This subsection discusses this issue. Specifically, assume that the researcher is able to estimate all the responses $\partial Y/\partial X$ in the formulas of the local MVPFs, (52) and (53), but she assumes that households are immobile so that $\partial n_i/\partial \tau_i = \partial w_i/\partial \tau_i = \partial p_i/\partial \tau_i = 0$ for each policy instrument $\tau_i \in P_i$. In this case, we have, for $z = n, x, l$:

$$LMVPF_i^{t_i^z}[\mu = 0] = \frac{-n_i b_i^z}{-n_i b_i^z - n_i t_i^x \dfrac{\partial x_i}{\partial t_i^z}} \tag{58}$$

$$LMVPF_i^{g_i}[\mu = 0] = \frac{\dfrac{n_i}{\lambda_i}\dfrac{\partial U_i}{\partial g_i}}{c - n_i t_i^x \dfrac{\partial x_i}{\partial g_i}} \tag{59}$$

where the argument $[\mu = 0]$ stands for household immobility. Subsequently, we define the argument $[\mu > 0]$ to indicate mobile households. In which direction are these "wrong" closed economy estimates of the MVPFs biased compared to the "true" open economy estimates accounting for household mobility? A general answer is that these bias could be in any direction depending on the estimated values of the mobility-driven responses $\partial n_i/\partial \tau_i$, $\partial w_i/\partial \tau_i$ and $\partial p_i/\partial \tau_i$. However, in some particular states of the 2-jurisdiction economy presented in section 2.4, the directions of these biases can be unambiguously characterized. Hereafter, we consider one of them. Specifically, assume that for each $i = 1, 2$:

$$(1 - t_i^l)\frac{\mathrm{d}w_i}{\mathrm{d}n_i} > \frac{\mathrm{d}p_i}{\mathrm{d}n_i} > 0 \tag{60}$$

as $\partial p_i/\partial n_i$ is expected to be always positive from (19), the notable assumption is the left-hand side inequality. It states that population inflows in a jurisdiction exert a sufficiently high upward pressure on the local wage for the disposable income to increase despite the simultaneous housing rent increase. This, of course, requires agglomeration economies ($\psi > 0$), so that wages actually increase as a response to population inflows $\partial w_i / \partial n_i > 0$ (see equation (24)).

Restating the expression of the MVPF with mobility (52) with respect to tax instruments, we obtain, for $z = n, x, l$:

$$LMVPF_i^{t_i^z}[\mu > 0] = \frac{-n_i b_i^z + n_i \overbrace{\left((1 - t_i^l)\frac{\partial w_i}{\partial t_i^z} - \frac{\partial p_i}{\partial t_i^z}\right)}^{<0}}{-n_i b_i^z - n_i t_i^x \frac{\partial x_i}{\partial t_i^z} - \underbrace{\left(n_i t_i^l \frac{\partial w_i}{\partial t_i^z} + r_i \frac{\partial n_i}{\partial t_i^z}\right)}_{<0}} < LMVPF_i^{t_i^z}[\mu = 0] \qquad (61)$$

where the sign in the numerator results from (29) and (60) and the sign in the denominator comes from (30). Condition (61) indicates that, under assumption (60), if the researcher assumes households are immobile leads to systematically overestimating the MVPF. More precisely, the numerator in (61) indicates that the researcher would ignore the following marginal welfare cost: taxation discourages some residents to live in the jurisdiction so that wages decrease due to agglomeration economies, which reduces the disposable income. Besides, the denominator in (61) also highlights a missing budgetary cost when using $LMVPF_i^{t_i^z}[\mu = 0]$. Indeed, the reduction in population reduces not only directly the tax revenues by $|r_i \partial n_i / \partial t_i^z|$ but also indirectly due to the resulting wage cut which reduces the labor tax revenues by $|n_i t_i^l \partial w_i / \partial t_i^z|$. If the model featured a property tax, the change in house prices would also have budgetary implications. 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 JEP) and often times the mobility elasticities are similar in magnitude to other behavioral responses, such as changes to labor supply (Saez, Slemrod and Giertz JEL).[14] Moreover, the capitalization effects of taxation also important (Feldstein and Wrobel; Siegloch and Loffler WP).

Because the qualitative effect of public good provision (attracting households) on mobility is the opposite of that of taxation (repelling households), the above development allows to immediately state that assessing $LMVPF_i^{g_i^z}[\mu = 0]$ (no mobility) instead of $LMVPF_i^{g_i^z}[\mu > 0]$ (with mobility)

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

leads to overestimating the MVPF. This can be seen by restating the MVPF, (53):

$$LMVPF_i^{g_i}[\mu > 0] = \frac{\frac{n_i}{\lambda_i}\frac{\partial U_i}{\partial g_i} + n_i \overbrace{\left((1-t_i^l)\frac{\partial w_i}{\partial g_i} - \frac{\partial p_i}{\partial g_i}\right)}^{>0}}{c - n_i t_i^x \frac{\partial x_i}{\partial g_i} - \underbrace{\left(n_i t_i^l \frac{\partial w_i}{\partial g_i} + r_i \frac{\partial n_i}{\partial g_i}\right)}_{>0}} > LMVPF_i^{g_i}[\mu = 0] \tag{62}$$

where the sign in the numerator results from (29) and (60) and the sign in the denominator comes from (31). By attracting new households in the jurisdiction, public good provision entails two mobility-induced benefits: (i) a welfare benefit due to the wage increase resulting from agglomeration economies and (ii) a budgetary benefit because more households and higher a higher wage increase not only all tax revenues, but the labor tax in a larger extent. Again, whether these effects are large or small is an empirical question. For welfare programs, the empirical evidence indicates substantial mobility effects (Agersnap and Kleven); education programs also attract households to various localities (Epple and Sieg cite); and public amenities also attract households (CITEXXX). Finally, capitalization effects are non-trivial (Oates), although wage effects resulting from agglomeration may be smaller for lower income households than higher income households (CITE XXX), so the validity of the assumption used to derive the bias may depend on the precise nature of the program.

3.4 Social MVPF

Contrary to Hendren (2016), we consider a multiple jurisdiction framework. Therefore, one may be interested in considering the overall effect of policy changes on the entire federal economy and then comparing this to the local MVPF. A federal planner accounts for interjurisdictional spillovers and fiscal externalities when determining the optimal policy. We define the federal planner's MVPF as the social MVPF as:

$$SMVPF \equiv \frac{W'(0)}{\sum_{i=1}^m \Delta_i'(0)} \tag{63}$$

where $W(\theta)$ is the social welfare function. To define the social welfare function we rely on McFadden et al. (1978) definition of the inclusive value:[15]

$$IV = \mathbb{E}\left[\max_{i=1,\dots,m}(V_i + e_i)\right] = \mu \log\left(\sum_{i=1}^m \exp\left(\frac{V_i}{\mu}\right)\right), \tag{64}$$

[15] See also Kline and Moretti (2014) (in that paper, equation 18) and Suárez Serrato and Zidar (2016) (in that paper, the unnumbered equation above equation 13) for example.

which is the expected value of the utility that an individual obtains from living in the alternative jurisdictions of the economy. The social welfare functions differs from the inclusive value IV, (64), in two respects. First, the social planner is interested in the expected utility of all individuals, not just the representative individual. Therefore, we multiply IV by the population of the economy N. Second, the social welfare function is expressed in units of the private numéraire good so that each individual's indirect utility V_i is divided by the marginal private utility of income λ_i. It follows that:[16]

$$W(\theta) = N\mathbb{E}\left[\max_{i=1,\ldots,m}\left(V_i(\theta)/\lambda_i + e_i\right)\right] = N\mu \log\left(\sum_{i=1}^{m} \exp\left(\frac{V_i(\theta)/\lambda_i}{\mu}\right)\right). \tag{65}$$

From this, it follows that:

$$W'(\theta) = \sum_{i=1}^{m} \frac{1}{\lambda_i} n_i V_i'(\theta), \tag{66}$$

which states that the marginal impact of the policy path on the social welfare function is equal to the mean marginal impact on jurisdictions' utilities weighted by their population share. It follows that (63) becomes:

$$SMVPF \equiv \frac{\sum_{i=1}^{m} n_i V_i'(0)/\lambda_i}{\sum_{i=1}^{m} \Delta_i'(0)} \tag{67}$$

This expression makes clear that if jurisdictions are symmetric, the social MVPF (67) is equal to the local MVPF (48). 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. For example, expressions (52)–(57) imply that:

$$SMVPF_i^{t_i^z} = \frac{\sum_{k=1}^{m} \frac{n_k}{\lambda_k}\frac{\partial V_k}{\partial t_k^z}}{\sum_{k=1}^{m} \frac{\partial \Delta_k}{\partial t_k^z}} = \frac{-n_i b_i^z + \sum_{j=1}^{m} n_j \left((1-t_j^l)\frac{\partial w_j}{\partial t_i^z} - \frac{\partial p_j}{\partial t_i^z}\right)}{-n_i b_i^z - \sum_{j=1}^{m}\left(n_j t_j^x \frac{\partial x_j}{\partial t_i^z} + n_j t_j^l \frac{\partial w_j}{\partial t_i^z} + r_j \frac{\partial n_j}{\partial t_i^z}\right)}, \quad \text{for} \quad z = l, n, x, \tag{68}$$

and:

$$SMVPF_i^{g_i} = \frac{\sum_{k=1}^{m} \frac{n_k}{\lambda_k}\frac{\partial V_k}{\partial g_k}}{\sum_{k=1}^{m} \frac{\partial \Delta_k}{\partial g_k}} = \frac{\frac{n_i}{\lambda_i}\frac{\partial U_i}{\partial g_i} + \sum_{\substack{j=1 \\ j\neq i}} \frac{n_j}{\lambda_j}\frac{\partial U_j}{\partial g_i} + \sum_{j=1}^{m} n_j \left((1-t_j^l)\frac{\partial w_j}{\partial g_i} - \frac{\partial p_j}{\partial g_i}\right)}{c - \sum_{j=1}^{m}\left(n_j t_j^x \frac{\partial x_j}{\partial g_i} + n_j t_j^l \frac{\partial w_j}{\partial g_i} + r_j \frac{\partial n_j}{\partial g_i}\right)}. \tag{69}$$

[16]See Appendix C for a proof of equation (65).

4 Policy reactions

In open economy models, fiscal competition implies that jurisdictions compete with each other for mobile tax or expenditure bases. At the local level, local governments might be viewed as being atomistic (Agrawal et al., 2020), especially in capital markets: infinitely many jurisdictions compete with each other for mobile factors. In this way, fiscal competition is like perfect competition among firms: jurisdictions do not react strategically with each other.

However, in the case of mobile labor and related factors, jurisdictions may have market power. Such market power may result from, for example, individuals being attached to a given metropolitan area and only willing to move within that area. In this world, mobility is local, rather than global in nature. As a result, jurisdictions will interact strategically (game theoretically) with each other. We consider the effects of this fiscal competition.

In this section, we are interested in policy changes initiated in jurisdiction i, via changes in t_i^l, t_i^x, t_i^n or g_i. Our purpose is to characterize the local and social MVPFs when the government of all other jurisdictions $j = 1, \ldots, m$, $j \neq i$ respond to these policy changes by altering their policy instruments t_j^l, t_j^x, t_j^n and g_j.

4.1 General equilibrium

In the equilibrium, all policy instruments of jurisdiction i, $P_i = \{t_i^l, t_i^x, t_i^n, g_i\}$, are exogenously set while the policy instruments of each jurisdictions $j \neq i$, $P_j = \{t_j^l, t_j^x, t_j^n, g_j\}$, are endogenously determined. Government $j \neq i$ acts as a Leviathan and seeks to maximize their tax revenues, taking as given their public spending, and tax choices of the other governments. The problem of government j consists of maximizing the net tax revenues:[17]

$$Tr_j = n_j r_j - cg_j = n_j \sum_{z=l,x,n} t_j^z b_j^z - cg_j \tag{70}$$

choosing the taxes t_j^l, t_j^x and t_j^n. The first order conditions are:

$$\frac{\mathrm{d}Tr_j}{\mathrm{d}t_j^s} = \frac{\partial n_j}{\partial t_j^s} r_j + n_j b_j^s + n_j \sum_{z=l,x,n} t_j^z \frac{\partial b_j^z}{\partial t_j^s} = 0 \qquad s \in \{l, x, n\} \tag{71}$$

and:

$$\frac{\mathrm{d}Tr_j}{\mathrm{d}g_j} = \frac{\partial n_j}{\partial g_j} r_j + n_j \sum_{z=l,x,n} t_j^z \frac{\partial b_j^z}{\partial g_j} - c \qquad = 0 \tag{72}$$

[17] In other words, the purpose of government j is to maximize the budget deficit g_j which it enjoys as as a rent to officials. The deficit cannot be too high since policy choices are subject to household mobility.

The $4(m-1)$ conditions (72) can be viewed as characterizing a partial Nash equilibrium in which the $M-1$ jurisdictions $j \neq i$ choose their 4 policy instruments. The 4 policy instruments of jurisdiction i are ex-ante exogenously set at their levels of the full Nash in which all M jurisdictions are competing.

The $2m$ equilibrium conditions (15) and (18), and the $4(m-1)$ optimality conditions (72) implicitly define the levels of the M populations n_i, the M housing rents p_i and the $4(m-1)$ policy instruments $P_j\{t^l_j, t^x_j, t^n_j\}$ as a function of jurisdiction i's policy instrument set $P_i = \{t^x_i, t^l_i, t^n_i, g_i\}$. For $j = 1, \ldots, m$, we can write the population and rent functions as $n_j(P_i)$ and $p_j(P_i)$. For $j = 1, \ldots, m$, with $j \neq i$, we can write the policy reaction functions as $t^l_j(P_i)$, $t^x_j(P_i)$, $t^n_j(P_i)$ and $g_j(P_i)$, or more synthetically, $P_j(P_i)$.

4.2 Responses

We aim to address the following question. How are the local MVPFs of jurisdiction i and that of each jurisdiction $j \neq i$ altered as governments respond to policy changes in jurisdiction i?

To this aim, consider at policy setting in which the levels of the jurisdiction i's policy instruments are arbitrarily set at levels $\overline{P_i} = \left\{\overline{t^x_i}, \overline{t^l_i}, \overline{t^n_i}, \overline{g_i}\right\}$. As characterized in th previous subsection, the equilibrium levels of the other jurisdictions' policy instruments are $P_j(\overline{P_i}) = \{t^l_j(\overline{P_i}), t^x_j(\overline{P_i}), t^n_j(\overline{P_i}), g_j(\overline{P_i})\}$, $j = 1, \ldots, m$ with $j \neq i$. It follows that the aggregate policy instrument set of all jurisdiction but i, $\mathbf{P}_{-i}$, defined in (27), is a function of the policy setting in jurisdiction i, so that we denote $\mathbf{P}_{-i}(\overline{P_i})$. The equilibrium population and rent functions in all jurisdiction $j = 1, \ldots, m$ (including i) are such that:

$$n_j(\overline{P_i}) = \widehat{n}_j\left(\overline{P_i}, \mathbf{P}_{-i}(\overline{P_i})\right), \qquad p_j(\overline{P_i}) = \widehat{p}_j\left(\overline{P_i}, \mathbf{P}_{-i}(\overline{P_i})\right), \tag{73}$$

where $\widehat{n}_j(\cdot)$ and $\widehat{p}_j(\cdot)$ are the general equilibrium functions determined in section 2.3 which give the population and rent in j for any vector of policy instruments $\mathbf{P} = (P_1, \ldots, P_M)$ in the economy.

We are now in a position to shed light on the new responses appearing due to the policy reactions of jurisdictions $j \neq i$ to jurisdiction i's policy changes. Consider a marginal increase in instrument $\tau_i \in P_i$. Differentiating $P_j(\overline{P_i})$, we obtain the following policy reactions in all other jurisdictions $j = 1, \ldots, m$ with $j \neq i$:

$$\frac{\partial \tau_j}{\partial \tau_i} \neq 0, \qquad \tau_i \in P_i, \tau_j \in P_j, \tag{74}$$

These policy responses directly affect the local MVPF of each jurisdiction j. They also indirectly affect the MVPF of all jurisdictions of the economy, including i, via changes in the population and the housing rent. This can be seen by differentiating the population and rent functions, (73) with respect to $\tau_i \in P_i$:

$$\frac{\mathrm{d}\mu_j}{\mathrm{d}\tau_i} = \frac{\partial\widehat{\mu}_j}{\partial\tau_i} + \sum_{\substack{k=1\\k\neq i}}^{m} \sum_{\tau_k\in P_k} \frac{\partial\widehat{\mu}_j}{\partial\tau_k}\frac{\partial\tau_k}{\partial\tau_i} \qquad \mu \in \{n; p, w, x\} \tag{75}$$

for all $j = 1, \ldots, m$ including i. In the absence of policy reaction, we would have $\mathrm{d}\mu_j/\mathrm{d}\tau_i = \partial\widehat{\mu}_j/\partial\tau_i$ as assumed in previous sections. For $\mu = n$, expression (75) indicates that in response to a marginal policy change in jurisdiction i, all other jurisdictions respond by altering all their policy instruments. This, in turn, entails population migrations. These population flows will alter all the local MVPFs in the economy.

4.3 LMVPFs

The own-effect local MVPFs (52) and (53) transform as:

$$LMVPF_i^{t_i^z} = \frac{-n_i b_i^z + (1-t_i^l)\dfrac{\mathrm{d}w_i}{\mathrm{d}t_i^z} - n_i\dfrac{\mathrm{d}p_i}{\mathrm{d}t_i^z}}{-n_i b_i^z - n_i t_i^x\dfrac{\mathrm{d}x_i}{\mathrm{d}t_i^z} - n_i t_i^l\dfrac{\mathrm{d}w_i}{\mathrm{d}t_i^z} - r_i\dfrac{\mathrm{d}n_i}{\mathrm{d}t_i^z}} \equiv \frac{\dfrac{n_i}{\lambda_i}\dfrac{\mathrm{d}V_i}{\mathrm{d}t_i^z}}{\dfrac{\mathrm{d}\Delta_i}{\mathrm{d}t_i^z}} \tag{76}$$

and:

$$LMVPF_i^{g_i} = \frac{\dfrac{n_i}{\lambda_i}\dfrac{\partial U_i}{\partial g_i} + (1-t_i^l)\dfrac{\mathrm{d}w_i}{\mathrm{d}g_i} - n_i\dfrac{\mathrm{d}p_i}{\mathrm{d}g_i}}{c - n_i t_i^x\dfrac{\mathrm{d}x_i}{\mathrm{d}g_i} - n_i t_i^l\dfrac{\mathrm{d}w_i}{\mathrm{d}g_i} - r_i\dfrac{\mathrm{d}n_i}{\mathrm{d}g_i}} \equiv \frac{\dfrac{n_i}{\lambda_i}\dfrac{\mathrm{d}V_i}{\mathrm{d}g_i}}{\dfrac{\mathrm{d}\Delta_i}{\mathrm{d}g_i}} \tag{77}$$

for $z = l, n, x$ and where the total derivatives are as defined in (75). The LMVPFs have the same shape as without policy reactions but the responses of population n_i, housing rent p_i and consumption x_i now include the policy reactions as defined in (75).

The cross-effect local MVPFs (56) and (57) become:[18]

$$LMVPF_j^{t_i^z} = \frac{\dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}t_i^z} + \sum_{s=l,n,x}\dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}t_j^s}\dfrac{\partial t_j^s}{\partial t_i^z} + \dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}g_j}\dfrac{\partial g_j}{\partial t_i^z}}{\dfrac{\mathrm{d}\Delta_j}{\mathrm{d}t_i^z} + \sum_{s=l,n,x}\dfrac{\mathrm{d}\Delta_j}{\mathrm{d}t_j^s}\dfrac{\partial t_j^s}{\partial t_i^z} + \dfrac{\mathrm{d}\Delta_j}{\mathrm{d}g_j}\dfrac{\partial g_j}{\partial t_i^z}}, \tag{78}$$

[18] Formally, these cross-effect MVPFs are obtained by appropriately including the terms of the own-effect MVPFs (76) and (77).

and:

$$LMVPF_j^{g_i} = \frac{\dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}t_i^z} + \sum_{s=l,n,x}\dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}t_j^s}\dfrac{\partial t_j^s}{\partial g_i} + \dfrac{n_j}{\lambda_j}\dfrac{\mathrm{d}V_j}{\mathrm{d}g_j}\dfrac{\partial g_j}{\partial g_i}}{\dfrac{\mathrm{d}\Delta_j}{\mathrm{d}g_i} + \sum_{s=l,n,x}\dfrac{\mathrm{d}\Delta_j}{\mathrm{d}t_j^s}\dfrac{\partial t_j^s}{\partial g_i} + \dfrac{\mathrm{d}\Delta_j}{\mathrm{d}g_j}\dfrac{\partial g_j}{\partial g_i}} \tag{79}$$

The new feature in the local MVPFs with policy reactions (78) and (79) is that the neighboring jurisdiction's MVPF now includes all the elements of the own-effect MVPF (76) and (77). This results from the fact that jurisdiction j reacts with its own policy instruments to policy changes in jurisdiction i. These reactions entail their own flows of population and price changes, which alter the utility and budget deficit in j.

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Appendix

A Wage response w to population changes

The purpose of this appendix is to prove conditions (23) and (24). To this aim, let us restate the firm's optimal conditions (21) and (22):

$$F_k = r \tag{80}$$

$$w = \frac{F - rk}{n} \tag{81}$$

in which index i and the arguments of the production function $F(n, k)$ have been removed for convenience. Moreover, derivatives are denoted with subscripts. This two-equation system defines k and w as functions of n. Differentiating both equations with respect to n, we obtain:

$$F_{kn} + F_{kk}\frac{\partial k}{\partial n} = 0 \tag{82}$$

$$\frac{\partial w}{\partial n} = \frac{1}{n}\left(F_n + (F_k - r)\frac{\partial k}{\partial n} - \frac{F - rk}{n}\right) \tag{83}$$

where subscripts stand for derivatives. Condition (82) directly implies:

$$\frac{\partial k}{\partial n} = -\frac{F_{kn}}{F_{kk}} \tag{84}$$

which proves (21). Inserting (80) into (83) and collecting terms, we obtain:

$$\frac{\partial w}{\partial n} = -\frac{F - F_n n - F_k k}{n^2} = \psi\frac{F}{n^2} \tag{85}$$

in which the second equality has been obtained using Euler's identity $(1+\psi)F = F_n n + F_k k$ resulting from the fact that F is homogeneous of degree $1 + \psi$. Equation (85) proves condition (22).

B Responses in the 2-jurisdiction case

The population conditions (15) can be written as:

$$n_1 = \frac{N}{1 + \exp(\mu \Delta V)} \tag{86}$$

$$n_1 + n_2 = N \tag{87}$$

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

$$V_i = U\left(\frac{1}{1 + t_i^x}[(1 - t_i^l)w_i - t_i^n - p_i], g_i, g_{-i}\right) \qquad i = 1, 2 \tag{88}$$

The equilibrium conditions reduce to condition (86) in which we plug $n_2 = N - n_1$ from (87). 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 (86) with respect to policy instrument $\tau \in \mathbf{P}$, we obtain:

$$\frac{\partial n_1}{\partial \tau} = -\frac{\mu n_1 n_2}{N}\left(\frac{\partial \Delta V}{\partial n_1}\frac{\partial n_1}{\partial \tau} + \frac{\partial \Delta V}{\partial \tau}\right) \qquad \text{so that,} \qquad \frac{\partial n_1}{\partial \tau} = -\frac{\mu \frac{\partial \Delta V}{\partial \tau}}{\frac{N}{n_1 n_2} + \mu \frac{\partial \Delta V}{\partial n_1}} \tag{89}$$

from which it follows that:

$$\frac{\partial n_1}{\partial t_1^n} = -\frac{\mu n_1 n_2 \left(1 + t_2^x\right)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{90}$$

$$\frac{\partial n_1}{\partial t_1^l} = -\frac{\mu n_1 n_2 w_1 (1 + t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{91}$$

$$\frac{\partial n_1}{\partial t_1^x} = -\frac{\mu n_1 n_2 x_1 (1 + t_2^x)}{D}\frac{\partial U_1}{\partial x_1} \qquad < 0, \tag{92}$$

$$\frac{\partial n_1}{\partial g_1} = \frac{\mu n_1 n_2 (1 + t_1^x)(1 + t_2^x)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right) \qquad > 0, \tag{93}$$

where

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

whose sign directly follows from assumption (28).

Let us turn to the responses of the consumption x_i to policy changes. Inserting (90)–(93) into (32) we obtain:

$$\frac{\partial x_1}{\partial t_1^n} = -\frac{1}{D}\left(N(1 + t_2^x) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2}\left((1 - t_2^l)\frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2}\right)\right) \qquad <0 \tag{94}$$

$$\frac{\partial x_1}{\partial t_1^l} = -\frac{w_1}{D}\left(N(1 + t_2^x) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2}\left((1 - t_2^l)\frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2}\right)\right) \qquad <0 \tag{95}$$

$$\frac{\partial x_1}{\partial t_1^x} = -\frac{x_1}{D}\left(N(1 + t_2^x) - \mu n_1 n_2 \frac{\partial U_2}{\partial x_2}\left((1 - t_2^l)\frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2}\right)\right) \qquad <0 \tag{96}$$

$$\frac{\partial x_1}{\partial g_1} = \frac{\mu n_1 n_2 \left(1 + t_2^x\right)}{D}\left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1}\right)\left((1 - t_1^l)\frac{\mathrm{d} w_1}{\mathrm{d} n_1} - \frac{\mathrm{d} p_1}{\mathrm{d} n_1}\right) \tag{97}$$

the last response implies that:

$$\operatorname{sign}\left(\frac{\partial x_1}{\partial g_1}\right) = \left((1 - t_1^l)\frac{\mathrm{d} w_1}{\mathrm{d} n_1} - \frac{\mathrm{d} p_1}{\mathrm{d} n_1}\right) \tag{98}$$

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

$$\frac{\partial x_2}{\partial t_1^n} = \frac{\mu n_1 n_2 \frac{\partial U_1}{\partial x_1}}{D} \left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{99}$$

$$\frac{\partial x_2}{\partial t_1^l} = \frac{\mu n_1 n_2 w_1 \frac{\partial U_1}{\partial x_1}}{D} \left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{100}$$

$$\frac{\partial x_2}{\partial t_1^x} = \frac{\mu n_1 n_2 x_1 \frac{\partial U_1}{\partial x_1}}{D} \left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{101}$$

$$\frac{\partial x_2}{\partial g_1} = -\frac{\mu n_1 n_2 (1 + t_1^x)}{D} \left(\frac{\partial U_1}{\partial g_1} - \frac{\partial U_2}{\partial g_1} \right) \left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{102}$$

It follows that:

$$\operatorname{sign}\left(\frac{\partial x_2}{\partial t_1^n} \right) = \operatorname{sign}\left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{103}$$

$$\operatorname{sign}\left(\frac{\partial x_2}{\partial t_1^l} \right) = \operatorname{sign}\left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{104}$$

$$\operatorname{sign}\left(\frac{\partial x_2}{\partial t_1^x} \right) = \operatorname{sign}\left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{105}$$

$$\operatorname{sign}\left(\frac{\partial x_2}{\partial g_1} \right) = -\operatorname{sign}\left((1 - t_2^l) \frac{\mathrm{d} w_2}{\mathrm{d} n_2} - \frac{\mathrm{d} p_2}{\mathrm{d} n_2} \right) \tag{106}$$

From conditions (90)–(106), it follows that in the case of household immobility, i.e. $\mu \to 0$,we have:

$$\frac{\partial n_1}{\partial t_1^n} \to 0 \qquad \frac{\partial n_1}{\partial t_1^l} \to 0 \qquad \frac{\partial n_1}{\partial t_1^x} \to 0 \qquad \frac{\partial n_1}{\partial g_1} \to 0 \tag{107}$$

$$\frac{\partial x_1}{\partial t_1^n} \to -\frac{1}{1 + t_1^x} < 0 \qquad \frac{\partial x_1}{\partial t_1^l} \to -\frac{w_1}{1 + t_1^x} < 0 \qquad \frac{\partial x_1}{\partial t_1^x} \to -\frac{x_1}{1 + t_1^x} < 0 \qquad \frac{\partial x_1}{\partial g_1} \to 0 \tag{108}$$

$$\frac{\partial x_2}{\partial t_1^n} \to 0 \qquad \frac{\partial x_2}{\partial t_1^l} \to 0 \qquad \frac{\partial x_2}{\partial t_1^x} \to 0 \qquad \frac{\partial x_2}{\partial g_1} \to 0, \tag{109}$$

C Social utility function

Since the e_i are e i.i.d., the distribution function of $\max_{i=1,\dots,m}(V_i/\lambda_i + e_i)$ is equal to

$$Q(z) = P\left[\max_{i=1,\dots,m}(V_i/\lambda_i + e_i) < z\right] \tag{110}$$

$$= P\left[V_1/\lambda_1 + e_1 < z, \dots, V_M/\lambda_M + e_M < z\right] \tag{111}$$

$$= P\left[e_1 < z - V_1/\lambda_1, \dots, e_M < z - V_M/\lambda_M\right] \tag{112}$$

$$= P\left[\bigcap_{i=1}^{m}(e_i < z - V_i/\lambda_i)\right] \tag{113}$$

$$= \prod_{i=1}^{m} F(x - V_i/\lambda_i) \tag{114}$$

$$\tag{115}$$

where F is given by (13) so that:

$$Q(z) = \prod_{i=1}^{m} \exp\left[-\exp\left(-\frac{z - V_i/\lambda_i}{\mu} - \gamma\right)\right] \tag{116}$$

$$= \prod_{i=1}^{m} \exp\left[-\exp\left(\frac{V_i/\lambda_i}{\mu}\right)\exp(-\gamma)\exp\left(-\frac{z}{\mu}\right)\right] \tag{117}$$

$$= \exp\left[-\sum_{i=1}^{m}\exp\left(\frac{V_i/\lambda_i}{\mu}\right)\exp(-\gamma)\exp\left(-\frac{z}{\mu}\right)\right] \tag{118}$$

$$= \exp\left[-\mathbf{S}\exp\left(-\frac{z}{\mu}\right)\right] \tag{119}$$

where

$$\mathbf{S} \equiv \exp(-\gamma)\sum_{i=1}^{m}\exp\left(\frac{V_i/\lambda_i}{\mu}\right) \tag{120}$$

Then:

$$q(z) = Q'(z) = \exp\left[-\mathbf{S}\exp\left(-\frac{z}{\mu}\right)\right] \times \frac{\mathbf{S}}{\mu}\exp\left(-\frac{z}{\mu}\right) \tag{121}$$

$$= \frac{\mathbf{S}}{\mu}Q(z)\exp\left(-\frac{z}{\mu}\right) \tag{122}$$

By definition,

$$W = N\int_{-\infty}^{\infty} zq(z)\mathrm{d}z \tag{123}$$

Consider the following change of variable:

$$x = \exp(-z/\mu) \iff z = \mu\log\left(\frac{1}{x}\right) \tag{124}$$

so that:

$$\mathrm{d}z = -\frac{\mu}{x}\mathrm{d}x \qquad\qquad \lim_{z\to-\infty} x = \infty \qquad\qquad \lim_{z\to\infty} x = 0$$

so that:

$$\begin{aligned} W &= -N\int_{\infty}^{0} \mu \log\left(\frac{1}{x}\right)\exp(-\mathbf{S}x)\frac{\mathbf{S}}{\mu}x\frac{\mu}{x}\mathrm{d}x \\ &= -N\mu\mathbf{S}\int_{0}^{\infty} \log x \exp(-\mathbf{S}x)\mathrm{d}x \\ &= N\mu(\log\mathbf{S} + \gamma) \end{aligned} \tag{125}$$

where the last equality is a standard Laplace transformation. Inserting the definition of **S** (120), we obtain:

$$W = N\mu \log \sum_{i=1}^{m} \exp\left(\frac{V_i/\lambda_i}{\mu}\right) \tag{126}$$