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A COMPUTABLE GENERAL EQUILIBRIUM MODEL OF INTERGOVERNMENTAL AID

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ABSTRACT

This paper introduces a computable general equilibrium model of intergovernmental relations in which heterogeneous agents (i) are endowed with income and houses, (ii) are fully mobile between multiple jurisdictions, and (iii) vote in both local and state elections to determine local property and state income tax rates. The model is calibrated to New Jersey micro tax data and used to study the general equilibrium effects of state government policies. Three different types of intergovernmental programs are analyzed: (i) redistributive revenue sharing, (ii) district power equalization and (iii) deductibility of local taxes. The approach facilitates a heretofore difficult comparative analysis in that it provides for an integrated investigation of these programs in a single general equilibrium model.

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1. Introduction

The purpose of national or state fiscal intervention into local affairs is generally two fold: (i) to correct for an alleged underprovision of local public goods (LPGs) by increasing their production in all communities,[1] and (ii) to adjust perceived inter-jurisdictional inequities in the provision of local public services.[2] Thus a mix of considerations aimed at increasing the overall level of LPGs and decreasing their interjurisdictional variance enters into any formulation of the appropriate types and levels of intergovernmental activity. Even when the relative weights assigned to these goals have been determined, however, political effects and general equilibrium (GE) adjustments make the task of predicting the short and long run outcomes of any particular national or state policy proposal a challenging one.[3]

With this in mind, we compare and evaluate several policy instruments within the context of the GE model introduced in Nechyba (1994a). This model allows for an investigation of the effects of intergovernmental programs on migration, property values, individual voting choices and aggregate local and state voting outcomes. A theoretical short run (partial equilibrium) framework as well as a computable GE model calibrated to micro tax data are developed, and inferences are drawn from several sets of policy simulations. More precisely, we focus on three broad types of policies a state government might pursue in order to achieve increases in the level of LPGs and decreases in its interjurisdictional variance: (i) general redistributive revenue sharing in the form of either matching or block aid; (ii) district power equalization (DPE), and (iii) deductibility of local property tax payments on state income tax forms. This facilitates a thorough comparative analysis in that it provides for an integrated investigation of all these programs in the context of a single GE model.

1.1. Why a Computable General Equilibrium Approach

The endogenous general equilibrium adjustments that must be taken into account to adequately

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1 Underprovision of LPGs due to fiscal competition occurs in, among others, Zodrow and Mieszkowski (1986). It can, of course, also result from spillovers. For a recent discussion of equity and efficiency arguments both for and against intergovernmental aid, see Oakland (1994) and Ladd and Yinger (1989, 1994).

2 Since migration tends to limit the effect of local redistribution, redistributive policies must generally be carried out by higher levels of governments. Brueckner (1983) shows that a central city's attempt to redistribute income stimulates urban flight. Epple and Romer (1991) and Cassidy, Epple and Romer (1989) find that while local redistribution is feasible despite mobility, its amount is limited due to anticipated capital losses by homeowners.

3 Henceforth we will refer to the higher level of government as the state government.

predict the effects of various competing proposals are so large in number and potential significance (see, for example, Inman (1978)) that a purely analytic treatment holds limited promise. In response to the recent changes in state education funding in Michigan, for example, local school districts will change policies to satisfy constituencies who are now responding to different incentives; agents, facing new opportunity sets, will migrate between districts; and land prices will adjust as a result. The fact that all these variables feed into each other in ways that are difficult to predict demonstrates the need for a unified approach that endogenizes all of them. Furthermore, regional differences between local jurisdictions make this conceptually difficult problem even more challenging.

For these reasons, we think that a flexible computable general equilibrium model that can be parameterized for various different regions holds promise as a potential tool for policy makers. Such an approach is flexible in the potential variety of possible region-specific set-ups, yet rigorous in its treatment of the general equilibrium nature of the policy problems at hand. This paper gives an initial demonstration of a simple version of a new computable general equilibrium model's analysis of the long-run difference between various intergovernmental programs for one New Jersey suburb. Since we are not comparing any specific policy proposals currently under discussion, we concentrate here on drawing broad policy inferences. It should be noted, however, that competing policy formulae could be ranked for different regions according to various social welfare functions as in Inman and Wolf (1976). Furthermore, the CGE program could easily be adapted for a variety of different applications.

The simulation program presented in this paper differs from previous programs in that it takes the preferences and endowments of individual actors as primitives and then lets the equilibrium prices, policies and migrations unfold. Past simulations, in no small part due to the lack of more powerful computers, specified reaction functions rather than individual preferences and endowments (see in particular, Inman and Wolf (1976)). Our approach therefore represents a significant improvement in that it endogenizes all variables of interest and allows us to observe the impact of policies at a very micro-level: we can potentially trace who moves where, who benefits and who loses, what happens to community compositions, which prices adjust and why, etc. These types of details are glossed over in past models.

We begin with a brief review of the literature on intergovernmental programs. Then our model and its computable general equilibrium derivative are introduced in Section 2, followed by the formal definition of different types of intergovernmental programs in Section 3. Section 4 briefly reviews the simulation algorithm used for the policy simulations presented in Section 5, and Section 6 provides some concluding comments.

1.2. Literature Review

Revenue sharing in the form of intergovernmental grants has been an important policy issue since its rise to political prominence during the Nixon administration. Most papers follow the basic model of Wilde (1968, 1971) in treating local communities as individual utility maximizers choosing between private and LPG consumption in a partial equilibrium world. Modifications and expansions of this framework can be found in Oates (1972), Bradford and Oates (1971), McGuire (1975,1979) and others. The model is convenient in that it allows for an easy microeconomic treatment of various grant types by treating them as modifications of a *single* budget constraint. A variety of important conclusions about the effects of different grants have been arrived at in this manner, and the basic framework has been modified to study the flypaper effect.[4] Recently, considerable sensitivity of local spending to institutional structures was demonstrated empirically in Romer, Rosenthal and Munley (1992), and Singh and Thomas (1989) use this basic set-up to model the grant process as a principal-agent problem where nonobservability of public good outputs prevents the use of an optimal grant system. While important insights have thus been gained, issues of vote aggregation and differences in local and state tax bases are ignored. Furthermore, the partial equilibrium context does not allow for an investigation of changes in migration patterns and adjustments of property values nor for an adequate comparison of different types of intergovernmental interaction.[5]

Whereas revenue sharing has been legislated mainly by the US Congress, the interest in DPE has grown out of state supreme court rulings, starting with *Serrano vs. Priest* in California, which have

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4 The flypaper effect refers to the empirical observation that national governments seem to be able to raise local taxes in a district, hand the revenues from this tax increase to the local government and effect an increase in local public good production. For a closer examination of potential causes for the flypaper effect within the model used in this paper, see Nechyba (1994b). For a review of some of the literature, see Gramlich (1977).

5 Wildasin (1983) departs from the partial equilibrium literature by offering a theoretical GE model where each community has many mobile renters and one immobile landowner who controls local policies. Thus, while there is still no explicit political process, the problem is phrased in a GE context. De Bartolome (1991) studies migration in a world with rich and poor agents who have different demands for education and demonstrates that efficiency dictates segregation of the types. Note that this result relies crucially on the stylized assumption of different tastes of the rich and poor. Generally, equity considerations would view greater income homogeneity across jurisdictions positively because of the reduced fiscal need this would engender in poor communities (see, for example, Gramlich (1985)).

struck down current financing schemes for public education as unconstitutional under the equal protection clauses of state constitutions.[6] In essence, the widespread use of property taxation as a means of financing education on a local level gives rise to large inter-school district variances in per pupil spending on education. DPE, it has been argued, could reduce these variances by setting tax bases equal across communities for funding purposes. The difference in what a community actually collects in tax revenues (using the real property tax base) and what it can use for funding education (using the state determined base) would be placed into a state-administered property tax fund in the case of high base communities and drawn from that fund in the case of low base communities. Rothstein (1992) has recently provided some econometric evidence that one version of DPE in Michigan has indeed had some success along the lines demanded by the courts, and Reschovsky (1980) also finds a moderate gain in horizontal equity from a tax base sharing scheme in Minnesota.[7] Furthermore, Mieszkowski's (1994) recent survey of school aid programs around the US adds some support to the relative effectiveness of DPE in equalizing school spending. While Feldstein (1975) agrees that DPE leads to higher levels of LPGs in poor districts, his results indicate that equalizing bases may in fact result in an inverse relationship between community wealth and LPG provision. Inman and Rubinfeld (1979), Inman (1977, 1978) and Bucovetsky (1982) cast some doubt on this prediction by emphasizing the role of GE price adjustments. Since low tax base communities become more attractive, higher property values in poor districts will undermine the redistributive impact by narrowing the difference between the real and the state assigned bases.[8]

Finally, the Reagan administration's attempt to disallow deductibility of state and local tax payments on federal income tax forms during the mid 1980's generated considerable interest in the fiscal effects of federal deductibility provisions. Although it is controversial in and of itself, even its proponents debate the relative merits of different types of local tax deductibility. Gramlich (1985), for example,[9] recommends targeting deductibility to poor areas, a policy that could lead to greater interjurisdictional income homogeneity as wealthy individuals find it in their interest to move to poor

6 While the initial focus of these court rulings was to sever the link between community wealth and educational expenditures, a more recent trend has been for courts to require equalization of per pupil spending. One third of all states have now adopted some form of DPE. (See Reschovsky (1994) for more details.)

7 See also a critical comment by Fox (1981) and its reply (Reschkovsky (1981)).

8 Some interesting but unrelated verbal arguments concerning DPE can be found in Fischel (1976). A further noteworthy paper that focuses on efficiency gains and redistribution effects in a metropolitan area is Zodrow (1984).

9 See also the comment by Chernick and Reschkovsky (1987).

districts. Noto and Zimmerman (1984), on the other hand, conclude that, in the case of sales taxes, the best alternative would be to set a floor for state and local deductions and only allow deductibility above that floor. Gramlich (1985) focuses in particular on two effects of removing deductibility that might affect even non-itemizing taxpayers who do not benefit from it directly: (i) since the tax price of LPGs rises for itemizers as deductibility is reduced, majorities may vote for fewer LPGs; and (ii) high income itemizers may move as a result of a change in deductibility. Holtz-Eakin and Rosen (1990) and Chernick and Reschovsky (1986) provide support for Gramlich's first conjecture by demonstrating that higher deductibility has a significant positive impact on property tax rates. In support of his second proposition, Gramlich estimates modest migration effects resulting from changes in deductibility rules, and Chernick and Reschovsky (1987) show that these become larger with additional state migrations. Similarly, Herzog and Schlottmann (1986) provide estimates of migration in a metropolitan area resulting from less deductibility. Luger (1988) gives a further look at the "mobility impulse".[10]

2. The Model

The computable general equilibrium (CGE) model developed here is calibrated to New Jersey data and is based on the theoretical model in Nechyba (1994a) where the existence of an equilibrium is proved. The main elements of both the general model as well as its CGE derivative are summarized in Table 1. The set N represents both the set of agents and the set of houses in the model, where $n \in N$ is defined as that agent who is initially endowed with house n.[11] A fixed community structure

$$C = \{C_{mh} \subset N \mid (m,h) \in M \times H, \bigcup_{h \in H} C_{mh} \neq \emptyset \ \forall \ m \text{ and } C_{mh} \cap C_{m'h'} = \emptyset \ \forall \ (m,h) \neq (m',h') \} \qquad (1)$$

is imposed on this set of houses and partitions it into a set of house types $H=\{1,\ldots,h,\ldots,\bar{h}\}$ spread over a set of communities $M=\{1,\ldots,m,\ldots,\bar{m}\}$. C_{mh}, then, is both the set of houses of type h in community m and the set of agents initially endowed with such houses. The CGE model defines $N=[0,1]$, $H=\{1,2,3\}$ and $M=\{1,2,3\}$, which implies the existence of nine different house endowment

[10] Several authors (Feldstein and Metcalf (1987), Holtz-Eakin and Rosen (1987), and Inman (1989)) have focused on the effect of deductibility on a community's choice of local tax base. In this paper we ignore that issue and concentrate on the impact of deductibility on local tax rates, public good levels, migration and property values.

[11] More precisely, the set of houses and consumers is defined as part of a measure space $(N,\mathcal{N},\mu)$ where μ is taken to be the Lebesgue measure. All subsets referred to are henceforth assumed to be measurable.

types (three house types in each of three communities). Each of these is assumed to be represented in the economy in equal numbers; i.e.

$$\mu(C_{mh}) = 1/9.^{12} \tag{2}$$

In addition to his house endowment, each agent n is also endowed with a strictly positive amount of private good $z(n)$ called income. The set of income levels is assumed to be finite which gives rise to a set of income classes $I = \{1,\ldots,i,\ldots,\bar{i}\}$. This implies that the house and income endowments jointly define a set of endowment types

$$E = \{E_{mhi} \mid (m,h,i) \in M \times H \times I\} \tag{3}$$

where $e_{mhi} \in E_{mhi}$ is an agent that falls into the income class i and is endowed with a house of type h in community m. Our CGE model contains five of these income classes (with incomes of 2, 3.5, 5, 6.5 and 8 roughly corresponding to household income levels scaled by $10,000) which, combined with the three house types in each of three communities, generates 45 endowment types each of which is represented equally in the economy; i.e.

$$\mu(E_{mhi}) = \frac{1}{45} \quad \forall\ (m,h,i) \in M \times H \times I. \tag{4}$$

Finally, agents are endowed with a utility function $u^n{:}M \times H \times R_+^{\bar{m}+2} \rightarrow R_+$ which takes as its arguments the community and house type the agent lives in, private good consumption $z \in R_+$, and a vector of public goods $(x_0, x_1, \ldots, x_{\bar{m}}) \in R_+^{\bar{m}+1}$ where x_0 is the state public good (SPG) and x_m (for $m \in M$) is the LPG produced in community m. In the CGE version, all agents have the same utility function which is defined so as to exclude the possibility of spillovers between jurisdictions:

$$u^n(m,h,x,z) = k_{mh}\, x_0^{\alpha} x_m^{\beta} z^{\gamma} \qquad \forall\ n \in N.^{13} \tag{5}$$

State and local public goods are produced according to production technologies defined by a set of

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[12] In the calibration of the model, houses in the 25th, 50th and 75th percentile of property value distributions for three different communities (high income, middle income, and low income) are used. We are therefore not suggesting that different house types in different communities in New Jersey appear in equal numbers, but rather discretize a continuum of houses within communities into equally sized segments of house types.

[13] This utility function satisfies all conditions necessary for the existence of an equilibrium (see Nechyba (1994a)). The parameters are set to be consistent with New Jersey micro tax data in a way described in Nechyba (1994b). (A more complete description of this procedure is available from the author, and a description of the data used can be found in Bogart (1990).) Preferences are assumed to be identical in this way not only for computational convenience but also because stratification results in Nechyba (1994a) imply that under these conditions, the equilibrium assignment of agents into house types is unique.

production functions $F = \{f_i : R_+ \rightarrow R_+ \mid i \in 0 \cup M\}$ which convert private goods directly into public goods. In the CGE model, we define public good levels as per capita spending on the public good, i.e.

$$f_0(z) = \frac{z}{\mu(N)} \text{ and } f_m(z) = \frac{z}{\mu(C_m)} \text{ for } m \in M.^{14} \tag{6}$$

The SPG is financed through a proportional income tax t_0, while LPGs are funded through proportional property taxes. All tax rates are set through absolute majority rule voting by members of the relevant constituencies who are assumed to be myopic in the sense that they take community compositions and property values as given when they go to the polls. This implies they do not calculate the election's general equilibrium price and migration effects.[15] Since local budgets have to balance, the relationship between t_m and x_m is therefore one to one (given any $\bar{t}_m$) and is defined by:

$$x_m(t_m) = \frac{t_m p(C_m)}{\mu(C_m)} \quad \forall\, m \in M, \tag{7}$$

where $p(C_m) = \sum_{h \in H} (\mu(C_{mh})\tilde{p}(C_{mh}))$ is the local property tax base which varies with the endogenously determined house price function $\tilde{p}: M \times H \rightarrow R_+$ that gives rise to a house price vector $p \in R_+^{\overline{mh}}$; i.e. the function $\tilde{p}$ assigns a unique price to each house type in each jurisdiction. This, combined with myopic voting and standard assumptions on preferences and technologies, is shown in Nechyba (1994a) to yield single peaked preferences over LPG levels (or, equivalently, over local property tax rates) which in turn implies the existence of local voting equilibria.[16]

Agents are also assumed to be myopic in their location decisions in that they take prices, other public good levels and other agents' locations as given when choosing their location. An equilibrium is simply defined as follows:

Definition: An *equilibrium (J,p,t,x)* is a list of population assignments to communities J, prices p, tax rates t and public good levels x such that:[17]

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[14] Note that this formulation of public production implicitly ignores the important issue of cost differences between jurisdictions highlighted in Ladd and Yinger (1989, 1994). It also abstracts away from peer effects which may be important in educational production functions (see Nechyba (1995)).

[15] Myopic voting is standard in this literature (Westhoff (1977), Dunz (1985), Epple, Filimon and Romer (1993)). Note that in equilibrium individual expectations implied by myopic voting are correct.

[16] Voters are assumed to vote separately on local and national issues. This produces a *structurally induced equilibrium* (Shepsle (1979)) in which voters hold fixed local public goods when voting in national elections and vice versa. The same conditions that guarantee a local voting equilibrium then also guarantee a state voting equilibrium. Note that the Cobb-Douglas utility specification implies that the order of the votes does not matter.

(i) prices clear the market; i.e. there is no excess demand or supply for any house;

(ii) all government budgets balance;

(iii) consumers cannot gain utility by moving; and

(iv) local property and state income tax rates are determined through majority rule voting.

3. Some Short Run Definitions and (Partial Equilibrium) Intuitions

We begin by defining the following four classes of intergovernmental policies:

Definition: (i) A *redistributive block grant program* $G=(\tilde{s},\tilde{T})\in \{(s,T)\in R_+^{\bar{m}+1} \mid \sum_{i=1}^{\bar{m}} s_i = 1 \text{ and } T\in R_+\}$ raises $\tilde{T}$ in income tax revenues and distributes $(\tilde{s}_1)\tilde{T},\ldots, (\tilde{s}_{\bar{m}})\tilde{T}$ to jurisdictions $1,\ldots,\bar{m}$ respectively.

(ii) A *redistributive matching grant program* $k\in R^{\bar{m}}$ raises $\sum_{i=1}^{\bar{m}} k_i t_i p(C_i)$ in income tax revenues and provides each district i with a grant equal to $k_i t_i p(C_i)$.

(iii) A *district power equalization program* $P\in R_+^{\bar{m}}$ raises $\sum_{i=1}^{\bar{m}} t_i(P_i - p(C_i))$ in income tax revenues and provides each district i with a grant equal to $t_i(P_i - p(C_i))$.

(iv) A *local tax deductibility program* $d\in R^{\bar{m}}$ assigns to each community i the percentage d_i of local taxes its residents can deduct from their income for state tax purposes.

We will assume that agents are immobile and prices are fixed in the short run. This allows us to use a simple familiar graph to analyze short run voter behavior. Given an equilibrium (J,p,x,t), Figure 1 generates the choice set for some agent n who resides in community i and house h. Since voters are assumed to hold fixed all prices, the SPG level and their location in making their local voting choices, these factors are held fixed in Figure 1 as well. The fourth quadrant (+,–) graphs the function $t(\bullet;i,p)$ that assigns to each level of x_i the required local tax rate t_i:

$$t(x_i;i,p) = \frac{f_i^{-1}(x_i)}{p(C_i)} \quad . \tag{8}$$

[17] Note that $J = \{J_{mh} \subset N \mid \mu(J_{mh})=\mu(C_{mh})\ \forall\ (m,h)\in M\times H\}$ and C are both partitions of N. The difference is that C assigns houses (and the *initial* distribution of agents) to house types and communities, while J gives the *equilibrium* assignment of agents to houses and communities. For a more formal definition of an equilibrium in this model, see Nechyba (1994a).

The second quadrant (–,+) graphs the relationship between private good consumption for individual n living in community i and the community tax rate t_i:

$$z_n(t_i;i,h,p) = (1-t_0)z(n) + p_n - (1+t_i)p_{ih} \tag{9}$$

(where t_0, $z(n)$, p_n (the price of the house he was endowed with) and p_{ih} are fixed in the short run). Note that the relationship between tax rates and LPG production in quadrant IV is identical for all residents of i, whereas the relationship in quadrant II is different for each agent type. Finally, the functions in quadrants IV and II are combined in quadrant I to form the choice set (ABO) bounded by

$$\tilde{z}_n(x_i;i,h,p) = z_n\left(\frac{f_i^{-1}(x_i)}{p(C_i)}\ ;\ i,h,p\right). \tag{10}$$

So long as f_i is concave, this choice set is convex. We define the choice set formally as:

Definition: The *choice set* for $n \in J_{ih}$ given p is $\{(x_i,z) \in R_+^2 \mid z \leq \tilde{z}_n(x_i;i,h,p)\}$.

It should be noted that two types of redistribution are brought about by the programs defined above. Consider, for example, a program G=(s,T): Income tax money is redistributed (i) from communities with low s_i's to communities with high s_i's, and (ii) from agents with relatively less property than income to those with relatively more property than income. The second type of redistribution takes place because state and local governments use different tax bases, which causes relative tax burdens to change even when there is no intercommunity redistribution. Therefore, *so long as the state income tax is used to fund intergovernmental programs, individual welfare effects depend not only on what community an individual resides in, but also his relative holdings of income to property.*

Furthermore, despite their apparent differences, matching grant, district power equalization and tax deductibility programs are all members of the same class of intergovernmental policies. While matching grants and district power equalization operate through quadrant IV in Figure 1, deductibility operates through quadrant II. Each program can, however, be expressed formally in terms of the other. Although these three programs are thus equivalent in that each can be stated in the language of the other, they are very different in the formats most commonly proposed. In particular, matching grants are usually discussed in terms of uniformly positive matching rates to raise the general level of

LPGs; district power equalization most often has "tax base equalization" as its goal; and deductibility is either applied uniformly or targeted to financially desperate "enterprise zones." Furthermore, matching grant and deductibility programs tend to be funded solely by higher levels of governments whereas DPE is often discussed in terms of revenue neutral transfers from high base communities to low base communities via a combination of positive and negative matching grants. We therefore analyze these special cases as distinct programs in the following sets of computable general equilibrium simulations.[18]

4. Computation of Equilibria

The CGE program begins with the information contained in Table 1 as well as a vector of initial house prices and an initial level of the SPG. It iterates to an equilibrium by first finding local and state election outcomes, then determining equilibrium prices given those outcomes, then using those prices (and the new community compositions) to update election results, and so forth. During each major iteration, the program iterates to find prices for given election outcomes.[19]

More precisely, the program uses the initial data in Table 1 to identify each community's median voter who takes prices, the SPG level and everyone's location as given. That voter's optimal choice determines the community's LPG level (and local property tax rate). Next, the median voter in the state election and the resulting SPG outcome (and state income tax rate) are identified.[20] Given these election results, the program iterates to find equilibrium property values. In particular, during every iteration, each agent's optimal location at the current prices is determined, and these prices are adjusted upward (by a fixed amount) if the house type in question was in excess demand during this and the past iteration and downward (by the same amount) if it was in excess supply during these iterations. If a particular house type alternated between being in excess demand and excess supply, the previous two prices are averaged. This process typically converges within twenty iterations. Once equilibrium prices have been found, i.e. once excess demands for all houses are zero, the program starts over with a new

[18] The effect of the four types of programs defined in this paper on individual choice sets is described by equations analogous to (8), (9) and (10) in an appendix which is available upon request from the author. Furthermore, the relationship between interjurisdictional and interpersonal redistribution as well as the equivalence of matching grants, district power equalization and deductibility are formally treated in two theorems with corresponding proofs. These can also be found in Nechyba (1994b) and are omitted here for space considerations.

[19] The program is written in GAMS (General Algebraic Manipulation System).

[20] Again, the median voter holds fixed all prices and everyone's location, as well as the already selected LPG levels.

major iteration by identifying median voters in the new community populations. The process continues until the LPG and SPG levels, the local and state tax rates and the prices have converged. Throughout the process, the value of each agent's *initial* house endowment is used to determine that agent's budget. Values typically converge within several major iterations and, due to the uniqueness of equilibrium assignments of agents into house types and communities, are only slightly sensitive to initial prices and SPG levels.[21]

The benchmark equilibrium without governmental interaction is presented in Table 2. LPG and SPG levels can be interpreted as per capita spending by local and central governments respectively. The LPG figures fall within the actual range of per pupil spending on education (roughly between $2500 and $5000) for Camden County in 1987 (for which the model was calibrated), while the SPG level is close to the combined per capita state and national spending. Agents separate into low, middle, and high income communities, but there is some overlap due to overlapping values of the k_{mh}'s (see Table 1). Higher income communities tend to have higher LPG levels and lower property tax rates, and property values (the value of yearly housing services) tend to increase in community wealth. The fact that property values are inversely related to property taxes in Table 2 is simply due the fact that property in community 3 is inherently (i.e. all else being equal) more desirable than property in community 2 which again is inherently more desirable than property in community 1. (This is reflected in the different values of k_{mh} as reported in Table 1.)[22]

Note that the only feature of Table 2 that is exogenous is the sum of the entries in the "Income" column. Each entry in that column represents the average household income within that community.

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21 In particular, as mentioned before, stratification results in Nechyba (1994a) state that, when preferences are identical, agents will separate into house types and communities in a way that makes this separation unique. Therefore, while the set of equilibria is not necessarily a singleton, it is unique in certain important dimensions (i.e. the assignment of agents into communities). Due to the limited number of house types, however, prices can vary within small intervals which implies that majority rule tax rates and public good levels can vary within small intervals. The program simply picks the first set of prices, public good levels and tax rates that satisfy the equilibrium conditions, but the assignment of agents is the same for any potential equilibrium. Therefore, there will occasionally be small deviations from persistent trends in the simulation results, but these are small enough not to detract from the overall conclusions.

22 It has been suggested that, were entrepreneurs to enter the model, they would choose to build houses solely in community 3 because of the higher property values. This is not necessarily the case. Property values here can be thought of as the value of both the land the houses are built on and the houses themselves. They are higher in community 3 than elsewhere because (i) land may be inherently more desirable in community 3 (scenery, lakes, trees, etc.) and (ii) a house of type i in community 3 may be bigger and better than a house of type i in other communities. (The fact that houses in all three communities are labeled 1, 2 and 3 should not necessarily be interpreted to mean that a house of type i in community m is identical to a house of type i in community m'. These differences could be due to exogenous phenomena such as zoning.) Thus, entrepreneurs would not automatically choose to build in community 3: while property values are higher, so are land costs and house construction. The fact that houses are extraordinarily expensive in Beverly Hills, for example, does not imply that entrepreneurs will build new houses only in Beverly Hills.

Since the average income endowment (see Table 1) is 5, the average of the entries in the income column will always be equal to 5. Everything else in the table is entirely endogenous, but relationships between the columns can be identified and may help to clarify the interpretation of the numbers:

Wealth: Since the economy is endowed with only income and houses, the total wealth in the economy is equal to the sum of all incomes (exogenous) and the sum of all property values (endogenous). For any given simulation, the following must therefore hold:

$$\sum_{i=1}^{3} (\text{Income}_i + \text{Property}_i) = \sum_{i=1}^{3} \text{Wealth}_i . \qquad (11)$$

Note that this has to hold for the table as a whole but not for each row in the table.[23]

Consumption: Since agents do not save in the model, monotonicity of preferences implies that the total private good consumption for an agent must be equal to the value of his endowment (wealth) minus his equilibrium house payment minus his endogenously determined local and state tax payments. This relationship therefore has to hold for all members of each community and thus must hold for the average values within the tables; i.e.

$$\text{Consumption}_i = \text{Wealth}_i - (1+\text{Prop.Tax}_i)*\text{Property}_i - \text{Inc.Tax}*\text{Income}_i . \qquad (12)$$

LPG: The local public good is simply the per capita spending by the local government which, in the absence of grants) is equal to the local property tax rate times per capita property values:

$$\text{LPG}_i = \text{Prop.Tax}_i * \text{Property}_i . \qquad (13)$$

SPG: The state public good is the per capita spending by the state (and national) government which, in the absence of fiscal interaction with the communities, is simply the state income tax rate times per capita income (which is exogenous and equal to 5):

$$\text{SPG} = \text{Inc.Tax}*5. \qquad (14)$$

All other variables in the table are determined endogenously and have no relation to other values except for those already pointed out. In particular, property values arise in the market process, and local and state tax rates result from the voting process. Average property values within communities are averages of the property values of the different houses in those communities (listed separately in Table 2.)

The policy simulations in the following section begin with the initial benchmark equilibrium of Table 2 and find the new equilibrium as different levels of a given intergovernmental program are

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[23] This is because individuals are mobile and thus take property wealth from other jurisdictions into and out of communities.

introduced. The new equilibrium is calculated in much the same way as the initial equilibrium except that the CGE program now begins with the benchmark equilibrium. Each agent's wealth, however, is now affected by price changes of his ***equilibrium*** house, not his initial house endowment (which he sold on his way to the benchmark equilibrium.) When different magnitudes of a program are simulated, the simulation always begins with the benchmark equilibrium; i.e. the following tables should not be read as if a program was slowly being phased in. In addition to the community averages reported in Table 2, the average (per capita) cost of each program is reported.

Finally, it is not necessarily the case that, as increasing levels of a program are introduced, all trends in all community averages need to be smooth and monotonic. In part this is due to issues raised in footnote 21, but it is also due to the fact that majority rule voting and migration processes are not smooth and that most reported values are averages. Small changes in LPG levels and property values may cause large migrations which in turn may cause changes in other variables. The identity of the median voter may change in unpredictable ways as the community composition changes. Further, income levels may jump while wealth levels (which include property wealth by agents who sold their houses in other communities) stay relatively constant. The main reason for reporting results for *many* levels of each program is to detect persistent trends rather than occasional deviations from those trends.

5. Long Run (General Equilibrium) Effects of Intergovernmental Programs

We begin by comparing the general equilibrium effects of equally funded matching and block grants, and then turn to investigate the strengths and weaknesses of the most often proposed types of district power equalization and local tax deductibility.

5.1. Matching vs. Block Grants

Table 3 lists the general equilibrium effects of various sizes of a redistributive block grant program

$$G = (s,T) = \left(\left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right), t_0 z(N)\right); \qquad (15)$$

i.e. a program that raises $t_0 z(N)$ in income tax revenues and distributes them to the three jurisdictions in equal amounts. Note that this program is redistributive because, although the grants to each jurisdiction are equal, the burden of financing the program falls relatively more heavily on jurisdictions whose income is larger. We contrast the results in Table 3 to results in Table 4 of equally funded matching grant programs

$$k = \left(\frac{t_0\, z\,(N)}{3 f_1^{-1}(x_1^k)}, \frac{t_0\, z\,(N)}{3 f_2^{-1}(x_2^k)}, \frac{t_0\, z\,(N)}{3 f_3^{-1}(x_3^k)} \right); \tag{16}$$

i.e. programs whose matching rates are set in such a way as to distribute $\frac{t_0\, z\,(N)}{3}$ in state income tax revenues to each of the three jurisdictions. The total level of funding for the two programs is thus determined by the income tax rate t_0 imposed by the state government (and listed in the first columns of Tables 3 and 4); in the case of program G, this results in exogenously determined equal lump sum grants, whereas for program k, the matching ratio for each jurisdiction i (but not the total amount of aid to that jurisdiction) is determined endogenously and depends on the equilibrium levels of x_i^k. For equal levels of t_0, programs G and k therefore provide the same level of funding to each jurisdiction, with the former providing it as a lump sum and the latter as matching aid.

Property values in community 1 (community 3) rise (fall) in both tables as higher levels of each program are introduced, but they rise (fall) consistently faster under matching grants than under equally funded block grants. These changes occur as income tax revenues are distributed mainly from community 3 to community 1 (thus making community 1 relatively more desirable), while only small amounts are distributed from community 2 to 1 (and thus property values in community 2 remain relatively unaffected.) At first the fact that property values rise more under matching grants than under block grants may seem to pose a puzzle because we know from a partial equilibrium analysis that median voters within communities should prefer block grants to equally funded matching grants, and we might thus expect property values to rise more under the former than the latter. While it is true that local median voters would value their property more highly under block aid than matching aid, property values are determined not based on local valuations but rather on *total* demand which includes the demand by outsiders. One of the main reasons property in community 1 is not in greater demand in the first place is that LPGs there are low. Thus, to outsiders, the greater stimulative impact of matching grants on LPG levels makes local property *more* valuable than it would be under block grants. In equilibrium, then, property values rise faster under matching grants than under block aid.

Although income migrates out of relatively high income communities into relatively low income communities under both programs in roughly the same magnitudes, changes in wealth levels (which include the net inflow of both income and property wealth) are much less dramatic. In fact, while wealth levels for each magnitude of the block grant program *fall* in community 1 and rise in community 2, they tend to rise moderately for both communities under most levels of matching grants. As wealth levels remain relatively constant in the poor community under block grants, we do not see private consumption giving way to LPG consumption as grant levels rise (until grant levels become high and then only by 8%). Under matching grants, on the other hand, even though wealth levels tend to *rise* in the poor community, private consumption is *falling* and giving way to substantial increases in LPGs. In fact, LPG consumption rises consistently and dramatically in *all* communities as the funding for matching grants increases (by between 40% and 55% for t_0=0.06), while, under block grants, it rises consistently only for community 2 (and then only by at most 12% for t_0=0.06).

Most partial equilibrium theoretical treatments (see, for example, Oates (1972)), including those undertaken in the context of the present model (Nechyba (1994b)), predict this higher LPG consumption under matching grants than under block grants. The familiar partial equilibrium hypothesis of greater local fiscal responses from matching grants is thus confirmed and strengthened by the general equilibrium results in Tables 3 and 4. As is well known, this is a direct result of the fact that matching grants make LPGs relatively cheaper while block grants leave relative prices unchanged.

The particularly dismal performance of block grants in eliciting local fiscal responses, however, is not predicted by partial equilibrium models. It arises in the CGE simulations as all the funding for the block grant programs has to be raised endogenously; i.e. in a general equilibrium world, no such thing as a system of "exogenous" grants exists: either grants are raised entirely within communities, or they are redistributive and therefore benefit some communities at the direct expense of others. It therefore becomes extremely difficult to raise sufficient funds for a system of block grants that will make an appreciable difference in LPGs in *any* community as well as impossible to design such a system that would result in increases of LPGs in *all* communities. Matching grant systems are able to overcome this problem by causing price effects that far outweigh any income effects, positive or negative, in all the communities involved. They are therefore able to increase LPGs not only in communities that are net beneficiaries of the implicit redistribution but also in those that are net losers under the system.

On the other hand, the change in relative prices brought forth by the matching program makes SPG production significantly more expensive. Thus, while bringing forth increased LPG levels, these programs may cause a decrease in SPG production of up to 5% (for t_0=0.06). Block grants, by not altering relative prices, cause little change in SPG levels and actually result in a slight increase in SPG production in some simulations of Table 3. The introduction of matching grants over block grants therefore has a substantially larger stimulative impact on *local* public spending at the cost of depressing *state* public spending.[24] (This difference between block and matching grants may in fact lie behind the greater willingness of central governments to give block grants.)

In addition to causing higher LPG *levels*, matching grants also seem slightly more effective at moderating interjurisdictional *variances* in public spending between low income and middle income communities. The ratio of public spending in community 2 to that in community 1, for example, falls from 1.43 to 1.36 (for t_0=0.06) while it actually *rises* to 1.46 under the block grants[25]. Under redistributive matching programs, the fact that price effects are relatively stronger in poorer communities explains both the increase in LPG levels as well as this moderate decrease in the variance.

Finally, neither program demonstrates any consistent advantage in reducing interjurisdictional disparities in fiscal capacity. As noted, average wealth in community 1 stays relatively constant for both programs, while it increases slightly in community 2 and falls slightly in community 3. On a more individual level, however, both programs, but more so the matching program, improve the welfare of residents who originally resided in the poor community by raising property values relative to those in communities 2 and 3 by over 7% under matching grants and by roughly half that under block grants (for t_0=6). Thus, while migration causes community wealth to remain relatively constant under both programs, matching grants benefit individuals in poor communities more than block grants. We summarize as follows:

Result 1: *In a general equilibrium environment,*

- *Matching grants, because of their price effects, are substantially more effective than block grants in persuading voters to lower their private consumption in favor of LPGs, but they also may cause voters to significantly reduce the SPG while block grants do not.*

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24 The last conclusion should be treated with some caution. The decrease in the SPG resulting from an increase in its price is, in part, due to the Cobb-Douglas utility specification. This result could change with different specifications, in particular one that would make SPGs and LPGs stronger complements than the LPG and the private good.

25 For lower levels of grant funding, block grants perform even worse.

- *Since grants have to be funded endogenously, block grants can never raise LPG levels in* all *communities and produce only slight increases in* some *communities. Due to their strong price effects, matching grants can achieve dramatic* universal *increases in LPGs.*
- *Matching grants, by causing relatively larger price effects in poor communities, are also more effective than block grants at reducing interjurisdictional variances in public spending. Neither grant type shows much consistent superiority in reducing disparities in fiscal capacities, but both (and especially matching grants) benefit residents of poor districts at the expense of residents elsewhere by raising their property values relative to those in other communities.*

Matching grants thus seem to outperform block grants in both the policy dimensions we are interested in: they are more effective at raising LPG production everywhere and at reducing existing inequities. We therefore now proceed to investigate the general equilibrium effects of various commonly proposed versions of these matching grants.

5.2. District Power Equalization (DPE)

In its purest form, a DPE program P is often envisioned as a program of property tax base redistribution with little or no involvement of the income tax system. In practice, however, state politicians seem to find it difficult to reduce a community's tax base and thus often aim to equalize tax bases at the highest base level (Fisher (1981)) or to simply raise low wealth communities to some average tax base level.[26] While the former program can be constructed so as to be entirely revenue neutral (rich districts lose to poor districts), the latter two cannot. We therefore analyze various levels of equalization under all of these schemes. In particular, we define levels of equalization for our computable general equilibrium economy as follows:

Definition: A DPE program P is *universal* and satisfies *x% base equalization* if

$$P = (P_1, P_2, P_3) = ((1 - \frac{2x}{100})\,\overline{P},\ (1 - \frac{x}{100})\,\overline{P},\ \overline{P}). \tag{17}$$

On the other hand, P is *partial* and satisfies *x% base equalization* if

[26] In fact, no US state has enacted a DPE program that reduces any community's local tax base (Reschovsky (1994)).

$$P = (P_1, P_2, P_3) = ((1 - \frac{2x}{100})\,\overline{P},\ (1 - \frac{x}{100})\,\overline{P},\ p(C_3)). \tag{18}$$

Furthermore, program P is *revenue neutral* if $\overline{P}$ is defined endogenously such that

$$\sum_{i=1}^{3} t_i \overline{P} = \sum_{i=1}^{3} t_i p\,(C_i) \tag{19}$$

Finally, P is *equalizing to base i* if $\overline{P} = p(C_i)$.

Thus, a universal program P satisfies 10% base equalization if the legally assigned local tax base P_1 is 10% lower than P_2 which in turn is 10% lower than P_3; and a partial program P satisfies 10% equalization if the legally assigned base P_1 is 10% lower than P_2 and community 3's base is unaffected by the program (although residents in community 3 may still have to pay higher income taxes to fund it). Note that whenever a DPE program is equalizing to a base other than the unique base that satisfies revenue neutrality, the program is either adding to the state treasury (if the base is below the revenue neutral base) or it is being subsidized through the state income tax.

Tables 5 and 7 report the GE results for both revenue neutral and non-neutral programs with various levels of equalization. Although their magnitudes differ, the basic trends within each of the tables are similar. With increasing levels of the programs, property values rise (fall) in those communities whose real base is below (above) the state guaranteed base. As poor (wealthy) communities become relatively more (less) attractive, income migration effects combine with these changes in property values to increase (decreasing) average wealth levels. Both income effects from migration and, more importantly, price effects implicit in the program cause sharp increases (decreases) in LPG levels even when actual tax rates stay relatively unchanged. As in the matching grants discussed in the previous section, the implicit matching rates of the DPE program give rise to changes in the relative price of the SPG. Under revenue neutrality, this relative price rises in the poor community (whose matching rate is positive) while it declines in the wealthy community (where the matching rate is negative). These effects offset each other under revenue neutrality (Table 5) in the political process and cause little change in the equilibrium SPG level as voters in the least affected community (community 2) are likely to be pivotal. As the program is increasingly funded through the state income tax (Table 7), however, universally positive matching rates cause the relative price of the SPGs to rise everywhere thus causing increasing declines in SPG levels as program levels rise.

The most striking result of these sets of simulations adds support to a conclusion reached by Feldstein (1975) that, while initially the relative level of LPG spending is directly proportional to community income and wealth, it ends up inversely proportional when bases are fully equalized. Local public spending equality therefore does not call for complete tax base equalization. While the narrowing of interjurisdictional differences in property values by definition undermines the redistributive effects of the base equalization programs[27] (as in Inman and Rubinfeld (1979), and Bucovetsky (1982)), simulation results in Table 6 indicate that its effect on local public spending is minor. In particular, LPG production under a universal and revenue neutral equalization program is shown to be only marginally larger in the short run (with migration and prices fixed) than in the long run (after GE adjustments) in community 1 and only marginally smaller in community 3. This contradicts the rather strong general equilibrium effect found in simulations based on reaction functions by Inman (1977, 1978). The reason for this is that, while the long run effect of rising (falling) property values in poor (wealthy) communities tends to undo DPE, the long run migration patterns strengthen it. More precisely, migration leads to increases of interjurisdictional income and wealth homogeneity (as poor (wealthy) communities become more (less) desirable). Since the capacity to pay taxes ultimately depends on the level of wealth in a community, this move towards greater interjurisdictional wealth equality implies a significant narrowing of the gap in fiscal capacity between poor and wealthy districts. The increased (decreased) local fiscal capacity in poor (wealthy) communities causes tax prices for current residents to fall (rise) at the same time as the presence of higher (lower) wealth voters in the poor (wealthy) community cause a shift in the position of the median voter to one that demands more (less) LPGs (even if relative prices remained unchanged). This, then, explains the dramatic narrowing of LPG levels both in the short *and* the long run.

While full equalization is "going too far," less than full revenue neutral DPE seems well suited to reducing or eliminating interjurisdictional variances in LPG levels without reducing SPG provision or raising the average level of LPGs. In fact, results in Table 5 actually point to a small (up to 3.5%) increase in SPG production as various degrees of revenue neutral DPE are introduced, while a large decrease (-6.5%) occurs in Table 7a where bases are equalized *universally* to the *highest* level (which

[27] Matching rates under DPE are inversely related to property tax bases. Therefore, as the property values in poor (wealthy) communities rise due to DPE, matching rates fall (rise).

makes the program necessarily not revenue neutral) and a smaller decrease (-1.1%) in Table 7b (where bases are equalized *partially* to the *middle* level.)[28] These differences are due to the fact that DPE, when not revenue neutral, can be extremely expensive both for partial and universal equalization (see Avg. Cost in Tables 7a and 7b). While the higher and universally non-negative matching rates implicit in universal equalization yield larger increases in LPGs in communities 1 and 2 (and only miniscule declines in community 3 where the matching rate is 0), partial DPE (Table 7b) achieves gains in addition to those under revenue neutrality only for the wealthiest community and mainly at the expense of community 2. Furthermore, partial DPE is no more successful at reducing either interjurisdictional inequities in the provision of LPGs or disparities in fiscal capacities than revenue neutral DPE (Table 5). Thus, partial DPE that leaves high wealth communities untouched seems to introduce a needless burden on state budgets; virtually identical results (and in some cases better results) can be achieved for non-wealthy communities through a revenue neutral universal DPE program. Universal DPE that equalizes to the highest base (Table 7a), however, can raise LPG levels everywhere and still maintain most equity gains of revenue neutral proposals. The cost of such a program is that it raises the relative price of SPGs to the point where significantly less may be produced by state governments.

Finally, it should be mentioned again that revenue neutrality has the advantage that it is guaranteed to benefit all residents of poor jurisdictions by focusing on interjurisdictional redistribution, whereas DPE programs that are not revenue neutral cause additional interpersonal redistribution through the state income tax system. Individual equity implications of non-revenue neutral DPE are therefore considerably more difficult to trace. We summarize as follows:

Result 2: *In a general equilibrium environment,*

- *Equality in spending on LPGs does not require full tax base equalization. In fact, this would cause an inverse relation between community wealth and LPG levels.*
- *While DPE is more effective in the short run because long run property value changes imply long run matching rates will fall in poor districts and rise in wealthy ones, its impact in the long run is only slightly less pronounced. This is due to the fact that in the long run, migration induced by DPE causes a significant narrowing of the fiscal capacity*

[28] It is because of the large infusion of state income tax revenue required to achieve high base equalization that Reschovsky (1994) concludes that achieving tax equity or wealth neutrality through DPE is "an elusive goal." Our results here indicate that state governments would indeed incur substantial costs for such a program.

gap between wealthy and poor districts which compensates for the lower matching rates.

- *Revenue neutral universal DPE is as effective at reducing interjurisdictional variances in LPG provisions and disparities in fiscal capacities as partial DPE programs that are not revenue neutral. Furthermore, revenue neutral DPE insures that SPG levels do not fall, whereas any DPE that is not fully funded will place stress on the state's resources. Finally, by preventing interpersonal redistribution through the income tax, revenue neutrality is more successful at raising utility levels for all residents in poor districts.*
- *Universal DPE which equalizes bases to the highest base entails higher and uniformly positive matching rates and is therefore most effective in persuading voters to give up private goods in favor of increased LPGs. At the same time, however, the change in relative prices may imply lower levels of SPGs than partial or revenue neutral DPE.*

5.3. Local Tax Deductibility

While advocates of DPE attempt to change local fiscal conditions by providing matching grants to local governments, these grants could equally well be provided directly to local residents by allowing them to deduct part or all of their local taxes on their state income tax forms. We define two commonly advocated forms of local tax deductibility:

Definition: • A program d is a *uniform deductibility program* if $d_i=d_j$ for all $i,j\in M$.

• A program d creates an *enterprise zone i* if $d_i>0$ and $d_j=0$ for all $j\neq i$.

General equilibrium results for various degrees of deductibility under uniform programs as well as a program creating an enterprise zone in community 1 are presented in Tables 8a and 9 respectively. While there are no migration effects under uniform deductibility when everyone is assumed to itemize, and thus no property value changes or changes in wealth (both of which therefore go unreported), property values and wealth levels rise significantly (up to 15% and 12% respectively) in community 1 and fall elsewhere when community 1 becomes an enterprise zone. This strengthens Gramlich's (1985) argument that a policy targeting deductibility to low income areas will lead to more equal income and wealth levels between jurisdictions while seeming to weaken his contention that high income itemizers may move as a result of a change in *uniform* federal deductibility laws. However, deductibility in Table 8a applies to all taxpayers, not just high income itemizers, which explains the apparent contradiction. In the simulations of Table 8b we assume that those occupying the houses with property values in the bottom one third of the distribution do not itemize. While little changes in terms of the increase in LPG production in community 3, community 2 (which now has some non-itemizers) experiences a less rapid increase in LPGs as increasing degrees of deductibility are introduced, and the increases in LPGs production in community 1 virtually vanish. Thus, wealthy communities become more attractive with higher deductibility causing both wealth and income to migrate *out* of poor communities and *into* wealthy ones.

In addition to resulting in larger disparities of fiscal capacities, deductibility in the presence of poor non-itemizers also, as noted, causes large increases in the interjurisdictional variance of LPG levels. Under uniform deductibility in Table 8, LPG levels rise by approximately 18-19% in all three communities when everyone itemizes, while consumption and SPG levels fall slightly. Thus, overall public spending increases, with a large increase in local spending and a small decrease in state spending. The uniformity in these increases across communities results from the equal matching rates implied by uniform deductibility. When one incorporates low-wealth homeowners that do not itemize deductions, however, this uniformity vanishes (Table 8b). Since most non-itemizers are residents in the low wealth community, few voters there receive a matching grant. This causes LPGs there to barely rise (2%) while they rise more in community 2 (6%) (where only one of three residents does not itemize) and substantially more (18%) in community 3 (where everyone itemizes). Since the growth in LPG levels as deductibility is increased rises with community wealth, deductibility of local tax payments in the presence of poor non-itemizers increases interjurisdictional inequities in public good provisions substantially.

Unlike uniform deductibility, creating an enterprise zone (Table 9) explicitly redistributes between communities causing sharp increases in LPGs in community 1 (up to 79%) while giving rise to small decreases elsewhere (between 1% and 3%). These decreases in other communities are small because of the absence of price effects; agents in those communities are worse off only to the extent that their income taxes have gone up to pay for the enterprise zone. When enterprise zones are relatively small (compared to the set of communities that are not enterprise zones), relatively small increases in income taxes are required to fund the program. These increases in income taxes result in SPG changes that are significantly smaller than under uniform deductibility and may not even necessarily be negative.

Result 3: *In a general equilibrium environment,*

- *Uniform deductibility causes no migration effects or changes in property values when all agents itemize, and, through uniform matching rates, produces relatively equal increases in LPGs and decreases in private good consumption in all communities. Furthermore, due to changing relative prices, somewhat lower levels of SPG production may occur.*
- *Uniform deductibility in the presence of poor residents who do not itemize deductions on their income tax returns, however, causes increases in interjurisdictional inequities not only because fewer residents in poor communities benefit from the program (which causes LPG levels to rise substantially faster in wealthier communities) but also because income and wealth migrate out of poor communities and into wealthy ones as wealthy communities become relatively more desirable (due to relatively higher LPG levels).*
- *The creation of enterprise zones, by keeping the cost of the program low and thus causing redistribution to occur mainly interjurisdictionally, can produce dramatic increases in LPG levels in poor areas (so long as it is possible for residents to take deductions even when they do not itemize). At the same time, enterprise zones lead to increases in private good consumption and only small decreases in SPG levels. Furthermore, migration of income and wealth into the enterprise zone occurs and results in higher property values and wealth levels. Finally, decreases in LPGs elsewhere are small because of the small levels of income taxes required to fund the program and the lack of adverse price effects outside the enterprise zone.*

6. Conclusion

This paper introduces a simple version of a new computable general equilibrium model of local public finance and fiscal federalism. It further applies the model to draw several broad policy inferences from general equilibrium simulations involving state and national grant programs.

In conducting the analysis in the context of a single general equilibrium model, the paper allows for a comparison of block grants and matching grants, as well as a detailed analysis of various forms of commonly proposed aid programs such as different district power equalization, deductibility and enterprise zone proposals. It thus demonstrates the short and long run tradeoffs involved in commonly discussed programs and points out the long run consequences inherent in any federal general equilibrium system.[29] Policy makers may be interested, for example, to see the tradeoffs involved in increasing interjurisdictional equity versus increasing overall local public good production, in the use of the local property tax versus the state income tax, in high versus low levels of funding and in generating political support for state versus local public goods. This paper represents a first step in setting up a framework to analyze these tradeoffs in a general equilibrium environment and provides a tool for policy makers to analyze competing proposals. It further provides a base model for studying other issues in fiscal federalism such as school voucher programs, interjurisdictional externalities (spillovers) and intrajurisdictional externalities (peer effects), zoning regulations and the choice of tax bases for state and local governments. Finally, the model can be expanded to include industrial and commercial players, a more endogenous housing stock as well as different types of political institutions. Work in these directions is currently in progress.

[29] Rather than recount the various findings regarding block and matching aid, district power equalization and deductibility of local taxes, we refer the casual reader to the *Results 1-3* summaries in Section 5.

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TABLE 1

Summary of Computable General Equilibrium Model Including Parameter Values

	General Model	CGE Version and Parameters
Community Structure	$C = \{C_{mh} \subset N \mid (m,h) \in M \times H\}$	$N=[0,1]; M=\{1,2,3\}; H=\{1,2,3\};$ and $\mu(C_{ih}) = \frac{1}{9}\ \forall (m,h)$
Endowment Types	$E = \{E_{mhi} \mid (m,h,i) \in M \times H \times I\}$	$I=\{1,2,3,4,5\};\ \mu(E_{mhi}) = \frac{1}{45}\ \forall\ (m,h,i)$; and $(z(e_{mh1}),\ldots,z(e_{mh5})) = (2, 3.5, 5, 6.5, 8)\ \forall\ (m,h)$
Preferences	$U = \{u^n: M \times H \times R_+^{\overline{m}+2} \to R_+ \mid n \in N\}$	$u^n(m,h,x,z) = k_{mh}\, x_0^{\alpha} x_m^{\beta} z^{\gamma}\ \forall\ n \in N$ where $(\alpha, \beta, \gamma) = (0.13, 0.06, 0.64)$, and $(k_{11},\ldots, k_{13}, k_{21},\ldots, k_{33}) =$ $(0.82, 0.89, 0.96, 0.85, 0.95, 1.05, 0.93, 1.03, 1.13)$
Production of LPGs	$F = \{f_m: R_+ \to R_+ \mid m \in M\}$	$f_m(z) = \frac{z}{\mu(C_m)} \Rightarrow x_m(t_m) = \frac{t_m\, p(C_m)}{\mu(C_m)}$
Production of SPG	$f_0: R_+ \to R_+$	$f_0(z) = \frac{z}{\mu(N)} \Rightarrow x_0(t_0) = \frac{t_0\, z(N)}{\mu(N)}$

TABLE 2

Benchmark Equilibrium Without Fiscal Interaction

Community Averages*						
	Income	Wealth	Property	Consump.	Prop. Tax	LPG
Community 1	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782
Community 2	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977
Community 3	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248

House Values				
	Type 1	Type 2	Type 3	SPG Level
Community 1	0.4350	0.6301	0.9000	0.7737
Community 2	0.5800	0.9799	1.5150	State Income Tax Rate
Community 3	0.9900	1.5600	2.1600	0.1547

*Note: All dollar values are scaled by $10 000. Property values are expressed as annual payments on a fixed rate mortgage at 7% interest. Property tax rates may appear high because they are tax rates on these annual payments, not on the full value of the property.

TABLE 3*

General Equilibrium Effects of a Redistributive Block Grant Program

$$G = (s,T) = \left(\left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3} \right), t_0 z(N) \right)^*$$

t_0	Income	Wealth	Property	Consum.	Prop. Tax	LPG	Inc. Tax	SPG	Avg. Cost
Community 1									
0%	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
1%	3.1000	4.2348	0.6672	2.8323	0.3272	0.2683	0.1568	0.7839	0.0500
2%	3.4000	4.3793	0.6769	2.9369	0.2462	0.2667	0.1561	0.7806	0.1000
3%	3.2000	4.2962	0.6745	2.9074	0.1711	0.2654	0.1571	0.7857	0.1500
4%	3.4000	4.3871	0.6696	2.9743	0.1030	0.2690	0.1583	0.7914	0.2000
5%	3.3408	4.3478	0.6666	2.9502	0.0584	0.2889	0.1574	0.7868	0.2500
6%	3.3759	4.3455	0.6684	2.9423	0.0000	0.3000	0.1577	0.7884	0.3000
Community 2									
0%	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
1%	5.4000	6.4113	1.0250	4.1254	0.3515	0.4103	0.1568	0.7839	0.0500
2%	5.3000	6.3685	1.0274	4.0898	0.3093	0.4178	0.1561	0.7806	0.1000
3%	5.3000	6.3926	1.0226	4.1007	0.2714	0.4275	0.1571	0.7857	0.1500
4%	5.3715	6.3792	1.0189	4.0602	0.2307	0.4351	0.1583	0.7914	0.2000
5%	5.4400	6.4028	1.0189	4.0707	0.1817	0.4351	0.1574	0.7868	0.2500
6%	5.5250	6.4068	1.0116	4.0453	0.1456	0.4473	0.1577	0.7884	0.3000
Community 3									
0%	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
1%	6.5000	7.6112	1.5651	4.5909	0.2371	0.4210	0.1568	0.7839	0.0500
2%	6.3000	7.5119	1.5554	4.5276	0.2053	0.4194	0.1561	0.7806	0.1000
3%	6.5000	7.5624	1.5542	4.5207	0.1744	0.4211	0.1571	0.7857	0.1500
4%	6.2285	7.4654	1.5432	4.4709	0.1402	0.4163	0.1583	0.7914	0.2000
5%	6.2192	7.4970	1.5627	4.4769	0.1073	0.4176	0.1574	0.7868	0.2500
6%	6.1000	7.4625	1.5347	4.4841	0.0755	0.4158	0.1577	0.7884	0.3000

* Equations (11) and (14) hold for this table as stated in the text. Equation (12) should be modified to include ($-t_0$*(Income$_i$)) on the left hand side, and equation (13) requires an additional term ($+t_0$*5).

TABLE 4*

General Equilibrium Effects of a Redistributive Matching Grant Program

$$\mathbf{k} = \left(\frac{t_0\, z(N)}{3 f_1^{-1}(x_1^k)}, \frac{t_0\, z(N)}{3 f_2^{-1}(x_2^k)}, \frac{t_0\, z(N)}{3 f_3^{-1}(x_3^k)} \right)$$

t_0	Income	Wealth	Property	Consum.	Prop. Tax	LPG	Inc. Tax	SPG	Avg.Cost
Community 1									
0%	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
1%	3.2000	4.3105	0.6696	2.8453	0.3997	0.3109	0.1550	0.7749	0.0500
2%	3.4000	4.4506	0.6818	2.9047	0.4039	0.3532	0.1532	0.7659	0.1000
3%	3.6000	4.4412	0.6866	2.8336	0.3880	0.3736	0.1518	0.7591	0.1500
4%	3.6000	4.5545	0.6903	2.9017	0.4016	0.4118	0.1504	0.7518	0.2000
5%	3.4000	4.4210	0.6866	2.7891	0.3810	0.4257	0.1491	0.7453	0.2500
6%	3.4000	4.3879	0.6903	2.7379	0.3696	0.4320	0.1472	0.7361	0.3000
Community 2									
0%	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
1%	5.2000	6.3402	1.0250	4.0559	0.3916	0.4464	0.1550	0.7749	0.0500
2%	5.0000	6.1552	1.0286	3.9112	0.3398	0.4308	0.1532	0.7659	0.1000
3%	5.3000	6.3145	1.0198	3.9495	0.3753	0.4977	0.1518	0.7591	0.1500
4%	5.2500	6.2493	1.0177	3.8666	0.3592	0.5094	0.1504	0.7518	0.2000
5%	5.1000	6.2448	1.0128	3.8370	0.3749	0.5759	0.1491	0.7453	0.2500
6%	5.4467	6.3881	1.0140	3.8560	0.3840	0.5879	0.1472	0.7361	0.3000
Community 3									
0%	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
1%	6.6000	7.6114	1.5676	4.5366	0.2669	0.4636	0.1550	0.7749	0.0500
2%	6.6000	7.6514	1.5469	4.4976	0.2999	0.5483	0.1532	0.7659	0.1000
3%	6.1000	7.4919	1.5420	4.4312	0.2656	0.5263	0.1518	0.7591	0.1500
4%	6.1500	7.4365	1.5323	4.3271	0.2652	0.5533	0.1504	0.7518	0.2000
5%	6.5000	7.5599	1.5262	4.3383	0.2632	0.5759	0.1491	0.7453	0.2500
6%	6.1533	7.4594	1.5311	4.2558	0.2596	0.5967	0.1472	0.7361	0.3000

* Equations (11) and (14) hold for this table as stated in the text. Equation (12) should be modified to include ($-t_0$*(Income$_i$)) on the left hand side, and equation (13) should now read as follows:

$$LPG_i = (1+k_i)*Prop.Tax_i*Property_i \quad \text{where } k_i = (t_0*5)/LPG_i .$$

TABLE 5*

General Equilibrium Effects of Universal and Revenue Neutral District Power Equalization

Base Equal.	Income	Wealth	Property	Consum.	Prop. Tax	LPG	Inc. Tax	SPG	Avg.Cost
Community 1									
None	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
25%	3.3000	4.4092	0.6742	2.9435	0.4179	0.2991	0.1545	0.7724	0.0000
20%	3.7200	4.5976	0.6874	3.0363	0.4138	0.3259	0.1584	0.7922	0.0000
15%	3.5000	4.5602	0.7198	3.0043	0.3987	0.3476	0.1569	0.7843	0.0000
10%	3.8000	4.7183	0.7318	3.1031	0.3960	0.3707	0.1562	0.7812	0.0000
5%	3.8000	4.7185	0.7342	3.0814	0.4005	0.3938	0.1602	0.8012	0.0000
Full	3.8000	4.7165	0.7462	3.0848	0.3916	0.4073	0.1561	0.7807	0.0000
Community 2									
None	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
25%	5.2000	6.3121	1.0382	4.0676	0.3881	0.4166	0.1545	0.7724	0.0000
20%	5.0800	6.1770	1.0202	3.9695	0.3749	0.3936	0.1584	0.7922	0.0000
15%	5.4000	6.2850	1.0382	4.0135	0.3721	0.3939	0.1569	0.7843	0.0000
10%	5.0000	6.1168	1.0370	3.9192	0.3660	0.3854	0.1562	0.7812	0.0000
5%	5.0000	6.0938	1.0262	3.8874	0.3693	0.3832	0.1602	0.8012	0.0000
Full	4.9000	6.1059	1.0322	3.9225	0.3741	0.3891	0.1561	0.7807	0.0000
Community 3									
None	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
25%	6.5000	7.5353	1.5442	4.5633	0.2745	0.3928	0.1545	0.7724	0.0000
20%	6.2000	7.4310	1.4980	4.5269	0.2830	0.3713	0.1584	0.7922	0.0000
15%	6.1000	7.3988	1.4860	4.5336	0.2842	0.3540	0.1569	0.7843	0.0000
10%	6.2000	7.4016	1.4680	4.5371	0.2915	0.3411	0.1562	0.7812	0.0000
5%	6.2000	7.3921	1.4440	4.5279	0.2955	0.3228	0.1602	0.8012	0.0000
Full	6.3000	7.3916	1.4356	4.5439	0.2985	0.3104	0.1561	0.7807	0.0000

* Equations (11), (12) and (14) hold for this table as stated in the text. Equation (13) should have ($Property_i$) substituted by the appropriate legal base as described by equation (17) where $\overline{P}$ is endogenously defined to satisfy equation (19).

TABLE 6

Partial and General Equilibrium Effects on LPGs Resulting from Varying Degrees of Universal and Revenue Neutral DPE

	Local Public Good Levels		
Base Equality	Com. 1	Com. 2	Com . 3
None	0.2782	0.3977	0.4248
0.25 - Short Run	0.3020	0.4139	0.3848
0.25 - Long Run	0.2991	0.4166	0.3928
0.20 - Short Run	0.3356	0.4088	0.3563
0.20 - Long Run	0.3259	0.3936	0.3713
0.15 - Short Run	0.3646	0.4044	0.3318
0.15 - Long Run	0.3476	0.3939	0.3540
0.10 - Short Run	0.3898	0.4006	0.3104
0.10 - Long Run	0.3707	0.3854	0.3411
0.05 - Short Run	0.4119	0.3972	0.2916
0.05 - Long Run	0.3938	0.3832	0.3228
Full - Short Run	0.4316	0.3943	0.2749
Full - Long Run	0.4073	0.3891	0.3104

TABLE 7*

General Equilibrium Effects of

Base Equal.	Income	Wealth	Property	Consum.	Prop. Tax	LPG	Inc. Tax	SPG	Avg.Cost
(a) Universal DPE when Bases are Equalized to the Highest Base									
Community 1									
None	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
20%	3.8000	4.6629	0.6970	2.9961	0.4053	0.3643	0.1523	0.7615	0.1430
10%	3.8000	4.7368	0.7534	2.9469	0.3710	0.4325	0.1495	0.7475	0.2485
Full	3.6000	4.6684	0.7858	2.8437	0.3408	0.4844	0.1447	0.7236	0.3475
Community 2									
None	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
20%	5.2000	6.1472	1.0298	3.8045	0.3616	0.4334	0.1523	0.7615	0.1430
10%	4.9000	6.0546	1.0394	3.6726	0.3526	0.4625	0.1495	0.7475	0.2485
Full	5.1000	6.1787	1.0442	3.6798	0.3470	0.4932	0.1447	0.7236	0.3475
Community 3									
None	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
20%	6.0000	7.4147	1.4980	4.4224	0.2731	0.4091	0.1523	0.7615	0.1430
10%	6.3000	7.4586	1.4572	4.3040	0.3036	0.4424	0.1495	0.7475	0.2485
Full	6.3000	7.4041	1.4212	4.2214	0.2899	0.4120	0.1447	0.7236	0.3475
(b) Partial DPE when Bases are Equalized to the Middle Base									
Community 1									
None	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
20%	3.7000	4.5531	0.6892	2.9666	0.4153	0.3350	0.1554	0.7769	0.0490
10%	3.7000	4.6873	0.7006	3.0750	0.4098	0.3652	0.1532	0.7659	0.0780
Full	3.7446	4.6878	0.7126	3.0344	0.4039	0.3946	0.1532	0.7658	0.1060
Community 2									
None	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
20%	5.2000	6.2213	1.0082	3.9735	0.3777	0.3808	0.1554	0.7769	0.0490
10%	5.0000	5.9193	0.9902	3.7354	0.3531	0.3496	0.1532	0.7659	0.0780
Full	5.0388	6.0866	0.9770	3.8552	0.3846	0.3757	0.1532	0.7658	0.1060
Community 3									
None	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
20%	6.1000	7.4642	1.5412	4.4965	0.2719	0.4190	0.1554	0.7769	0.0490
10%	6.3000	7.6051	1.5208	4.5578	0.3044	0.4629	0.1532	0.7659	0.0780
Full	6.2166	7.4150	1.4998	4.4157	0.2770	0.4148	0.1532	0.7658	0.1060

* Equations (11) and (14) hold for this table. Equation (12) should include (-(Avg.Cost/5)*(Income_i)) on the left hand side, and equation (13) should have (Property_i) substituted by the appropriate legal base as described by equation (17) with $\bar{P}=\text{Property}_3$ for (a) and equation (18) with $\bar{P}=\text{Property}_2$ for (b).

TABLE 8*

General Equilibrium Effects of Varying Degrees of Local Tax Deductibility

% Deductible	Income	Consump.	Prop. Tax	LPG	Inc. Tax	SPG	Avg.Cost
(a) When All Homeowners Itemize							
Community 1							
0%	3.3000	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
20%	3.3000	2.9387	0.4375	0.2866	0.1572	0.7741	0.0119
50%	3.3000	2.9260	0.4592	0.3008	0.1614	0.7749	0.0321
80%	3.3000	2.9124	0.4847	0.3175	0.1658	0.7737	0.0553
100%	3.3000	2.9033	0.5043	0.3303	0.1688	0.7707	0.0733
Community 2							
0%	5.2000	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
20%	5.2000	4.0633	0.3999	0.4099	0.1572	0.7741	0.0119
50%	5.2000	4.0428	0.4199	0.4304	0.1614	0.7749	0.0321
80%	5.2000	4.0210	0.4436	0.4547	0.1658	0.7737	0.0553
100%	5.2000	4.0063	0.4618	0.4734	0.1688	0.7707	0.0733
Community 3							
0%	6.5000	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
20%	6.5000	4.5422	0.2784	0.4372	0.1572	0.7741	0.0119
50%	6.5000	4.5173	0.2917	0.4580	0.1614	0.7749	0.0321
80%	6.5000	4.4909	0.3074	0.4827	0.1658	0.7737	0.0553
100%	6.5000	4.4731	0.3195	0.5016	0.1688	0.7707	0.0733
(b) When Owners of Low Prices Houses Do Not Itemize							
Community 1							
0%	3.3000	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
20%	3.3000	2.9462	0.4236	0.2775	0.1576	0.7787	0.0093
50%	3.3055	2.9403	0.4316	0.2848	0.1608	0.7793	0.0247
80%	3.1400	2.8220	0.4293	0.2833	0.1653	0.7850	0.0415
100%	3.1500	2.7965	0.4292	0.2832	0.1656	0.7742	0.0538
Community 2							
0%	5.2000	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
20%	5.2000	4.0738	0.3872	0.3968	0.1576	0.7787	0.0093
50%	5.1836	4.0471	0.3915	0.4013	0.1608	0.7793	0.0247
80%	5.0600	4.0533	0.3958	0.4057	0.1653	0.7850	0.0415
100%	5.0500	4.0595	0.4109	0.4212	0.1656	0.7742	0.0538
Community 3							
0%	6.5000	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
20%	6.5000	4.5397	0.2783	0.4370	0.1576	0.7787	0.0093
50%	6.5109	4.5489	0.2919	0.4582	0.1608	0.7793	0.0247
80%	6.8000	4.6284	0.3074	0.4827	0.1653	0.7850	0.0415
100%	6.8000	4.6538	0.3196	0.5018	0.1656	0.7742	0.0538

* See the note at the bottom of Table 9.

TABLE 9*

General Equilibrium Effects of Varying Degrees of Deductibility for Community 1 only

% Deduct.	Income	Wealth	Property	Consum.	Prop. Tax	LPG	Inc. Tax	SPG	Avg.Cost
Community 1									
0%	3.3000	4.3900	0.6550	2.9462	0.4247	0.2782	0.1547	0.7737	0.0000
50%	3.3000	4.4107	0.6718	2.9317	0.4573	0.3072	0.1589	0.7863	0.0082
100%	3.4000	4.5579	0.6838	3.0480	0.4971	0.3399	0.1589	0.7764	0.0181
150%	3.7000	4.6868	0.7090	3.0951	0.5343	0.3788	0.1609	0.7740	0.0305
200%	3.7000	4.4796	0.7150	3.0585	0.5995	0.4287	0.1680	0.7918	0.0482
250%	3.7000	4.7000	0.7546	3.0203	0.6603	0.4983	0.1739	0.7974	0.0721
Community 2									
0%	5.2000	6.3027	1.0250	4.0753	0.3880	0.3977	0.1547	0.7737	0.0000
50%	5.2000	6.2602	1.0178	4.0142	0.3923	0.3992	0.1589	0.7863	0.0082
100%	5.2333	6.1920	1.0058	3.9670	0.3855	0.3877	0.1589	0.7764	0.0181
150%	5.0000	6.0690	0.9962	3.8856	0.3843	0.3828	0.1609	0.7740	0.0305
200%	5.0000	6.0781	0.9650	3.8892	0.3981	0.3842	0.1680	0.7918	0.0482
250%	5.1000	6.0493	0.9434	3.8318	0.4103	0.3871	0.1739	0.7974	0.0721
Community 3									
0%	6.5000	7.5573	1.5700	4.5568	0.2706	0.4248	0.1547	0.7737	0.0000
50%	6.5000	7.5815	1.5628	4.5649	0.2711	0.4236	0.1589	0.7863	0.0082
100%	6.3667	7.4820	1.5424	4.5072	0.2729	0.4209	0.1589	0.7764	0.0181
150%	6.3000	7.4821	1.5328	4.5147	0.2747	0.4211	0.1609	0.7740	0.0305
200%	6.3000	7.4203	1.4980	4.4447	0.2801	0.4195	0.1680	0.7918	0.0482
250%	6.2000	7.4119	1.4632	4.4527	0.2854	0.4177	0.1739	0.7974	0.0721

* Equations (11) and (13) hold for this table as stated in the text. Equation (12) is the same for communities 2 and 3, but for community 1 the term (Inc.Tax*($Income_i$–%Deduct.*($Prop.Tax_i$*$Property_i$)) should be substituted for (Inc.Tax*$Income_i$). Equation (14) should read:

$$SPG = Inc.Tax * (5-(1/3)*(\%Deduct*Prop.Tax_1*Property_1)).$$

A similar revision of the equations is required for some of the entries in Table 8.