Capitalization, Decentralization, and Intergenerational Spillovers in a Tiebout Economy with Durable Public Goods

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Introduction

The focus of our study is Durable Local Public Goods (DLPG) in an Overlapping Generations Economy (OLG).

These are public goods provided by competing localities that are passed from one generation to the next.

Examples include things like roads, schools, parks, libraries and other types of infrastructure.

This is in contrast to nondurable public goods like garbage collection, police and fire protection, and most types of services provided by city employees.

DLPGs

DLPGs have four interesting features:

- Intergenerational spillovers
- Durability
- Nonrivalry
- Localness

Durability and intergenerational spillovers

Building a durable good, public or private, necessarily implies that some benefits are transfered forward to the next generation.

What would motivate the current generation to internalize the benefits its decisions generate for the next?

Intergenerational spillovers can:

- flow forward (paying for college education of your kids)

- flow backward (paying for the retirement of your parents)

and need not involve durable goods.

Tiebout literature

Will Interjurisdictional competition will lead to efficient provision of through the capitalization of differences in public good levels into property values?

Nondurable goods should not be capitalized at all.

If the next generation's public goods choice is not related to the previous generation's decision, what is there to be capitalized?

Thus, to study local capitalization, DLPGs are essential.

Tiebout literature

The empirical literature strongly confirm the existence of capitalization effects.

Neighborhoods with better schools, less crime, more amenities have higher property values.

The theoretical literature on the capitalization is limited.

- Static models
- Partial equilibrium
- Built in exogenous frictions or inefficiencies

Main contribution

We consider a multijurisdictional, general equilibrium, finite period, OLG economy with DLPGs.

In particular, our land market is fully closed and property values are not pinned down by appealing to an exogenously set price of undeveloped land or other "outside offer".

We show that when lot sizes, and therefore jurisdictional populations, are fixed, interjurisdictional competition forces full capitalization of durable local public goods provision.

Thus, capitalization is sufficient to internalize the intergeneration spillovers implicit in the provision of DLPGs.

Main contribution

Intergenerational spillovers are not internalized, however, when public goods are provided centrally.

Thus, decentralized provision is essential for this result in the context of this model.

Formally, a Tiebout equilibrium exist and are always first best.

The Model

Consider a simple finite horizon, overlapping generations economy with one private consumption good, c, and one durable local public good (DLPG), G.

Agents are born with an endowment of ω units of private good, but no land.

Young agents buy land from old agents and enjoy whatever DLPG exists in the jurisdiction.

Old agents sell their land, eat the proceeds, and then go on their just reward.

Young agents divide what is left over from their land purchases between consumption and investments in DLPG.

The Model

All agents born between periods 1 and $T-1$ have identical utility functions:

$$U(c_{t,t}, c_{t,t+1}, G_t) = c_{t,t} + \rho c_{t,t+1} + V(G_t) \quad \text{for} \quad t = 1, ..., T-1.$$

where V is a strictly increasing and strictly concave C^2 function, and ρ is the exogenous discount factor.

Agents born in period zero and period T, on the other hand, have utility functions that account for the timing of consumption:

$$U(c_{0,1}) = c_{0,1},$$

$$U(c_{T,T}, G_T) = c_{T,T} + V(G_T)),$$

We denote additions to the DLPG stock from young agents by g and assume one unit of private good produces one unit of DLPG.

We assume that DLPG depreciate over time with a survival rate of δ.

This implies that DLPG evolves according the following rule

$$G_t^j = \delta(G_{t-1}^j + g_{t-1}^j).$$

The Model

DLPGs are provided by local jurisdictions indexed $j \in \{1, \ldots, J\} \equiv \mathcal{J}$.

Each jurisdiction contain L plots of indivisible land. Each period, a generation of young agents is born indexed $i \in \{1, \ldots, I\} \in \mathcal{I}$ where $I = J \times L$.

Young agents buy a plot of land from old agents at prices p_t^j and thereafter enjoy the services of the DLPG that is currently in place.

In the next period, the now old agents sell their land to the newly born young agents, consume this and leave the economy. Old agents do not consume DLPG.

$j \in \{1, \ldots, J\} \equiv \mathcal{J}$: jurisdictions.

$\ell \in \{1, \ldots, L\} \equiv \mathcal{L}$: plots of land in each jurisdiction.

$i \in \{1, \ldots, I\} \equiv \mathcal{I}$, individuals where $I = J \times L$.

$t = 1 \ldots, T$ periods.

$c^i_{t,t} \in \Re^1_+$: private good consumed in period t by agent i born in period t.

$c^i_{t,t+1} \in \Re^1_+$:private good consumed in period $t+1$ by agent i born in period t.

ω: private good endowment possessed by each agent in the period he is born.

$G^j_t \in \Re^1_+$: DLPG in jurisdiction j in period t.

$g^j_t \in \Re^1_+$: private good added to the existing DLPG stock in jurisdiction j in period t.

δ: the survival rate of capital.

p^j_t the price of a plot of land in jurisdiction j at time t

Planner's problem

We begin by stating the planner's problem.

The planner's objective is to maximize the sum of discounted utilities over all periods.

Given the concavity of V and the symmetry of agents and jurisdictions, this is equivalent to maximizing the sum of utilities of a representative agent from each period at an equal treatment allocation.

Thus the planner maximizes the following:

Planner's problem

$$\max W \equiv \sum_{t=0}^{T} \beta^{t-1} U_t$$

subject to

$$\omega = c_{t-1,t} + c_{t,t} + \frac{g_t}{L} \text{ for } t \in \mathcal{T}$$

$$G_t = (1-\delta)\left(G_{t-1} + g_{t-1}\right) \text{ for } t = 2, \ldots, T$$

$$g_t \geq 0 \text{ for } t \in \mathcal{T}$$

$$L\omega - g_t \geq 0 \text{ for } t \in \mathcal{T}$$

where

$$U_0 = c_{0,1}$$

$$U_t = c_{t,t} + \beta c_{t,t+1} + V(G_t) \text{ for } t = 1, \ldots, T-1$$

$$U_T = c_{T,T} + V(G_T).$$

Planner's problem

Note that from the planners perspective, it does not matter whether young or the old agents consume whatever private good is not invested in DLPG. Thus, substituting within period private goods resource constraint the planner's problem becomes:

$$
\begin{aligned}
\max_{g_1,\ldots,g_T,G_2,\ldots,G_T} W = & \sum_{t=1}^{T} \beta^{t-1} \left(w - \frac{g_t}{L} + V(G_t) \right) \\
& + \sum_{t=1}^{T} \beta^{t-1} \lambda_t \left((1-\delta) \left(G_{t-1} + g_{t-1} \right) - G_t \right) \\
& + \sum_{t=1}^{T} \beta^{t-1} \theta_t g_t + \sum_{t=1}^{T} \beta^{t-1} \phi_t (L\omega - g_t).
\end{aligned}
$$

where λ_t, θ_t and ϕ_t are the respective Lagrangian multipliers associated with feasibility constraints and the two sets of nonnegativity constraints.

Solving this gives us the following result:

Lemma 1. *The socially optimal steady-state level of DLPG is determined by:*

$$V'(G_{ss}) = \frac{1}{\beta\,(1-\delta)\,L} - \frac{1}{L}$$

and the socially optimal steady-state value of DLPG investment g_{ss}

$$g_{ss} = \frac{\delta G_{ss}}{1-\delta}.$$

We are now able to provide a full characterization of the solution to the planner's problem.

Theorem 1. *Assume $g_{ss} < L\omega$, and $G_{ss} > G_1$. Then the socially optimal levels of DLPG relate to the socially optimal steady-state level in the following manner:*

$$\beta\left(V'(G_{ss}) - V'(G_t)\right) = \frac{\theta_{t-1}}{1-\delta} - \beta\theta_t - \frac{\phi_{t-1}}{1-\delta} + \beta\phi_t \text{ for } t = 1, \ldots, T-1.$$

Moreover, the solution to the planner's problem is the following:

(i) $g_t^* = L\omega$ *from* $t = 1$ *to some* t' *(note that* t' *may equal* 1 *or* $T-1$*)*

(ii) $L\omega > g_{t'+1}^* \geq 0$

(iii) $g_t^* = g_{ss}$ *for period* $t'+2$ *to some period* $t'' \geq t'$ *or* $g_{t'+2}^* = 0$

(iv) $g_t^* = 0$ *for period* $t''+1$ *to* T*.*

Theorem 2. *Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed. Then the solution to the planner's problem becomes:* $g_1^* = \frac{G_{ss}-(1-\delta)G_1}{1-\delta}$, $g_t^* = g_{ss} = \frac{\delta G_{ss}}{1-\delta}$ *and* $G_t^* = G_{ss}$ *for* $t \in \mathcal{T}^O$, *and* $g_T^* = -G_T^* = -G_{ss}$.

The non-negativity constraints require that consumption and investment be non-negative.

Without them, the planner:

- invests enough in period 1 to get to the optimal steady state in period 2
- invests enough to maintain SS DLPG level util period $T-1$
- disinvests all the DLPG in period T: $g_T^\star = -G_{ss}$.

A feasible allocation $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ and a price system $\mathbf{p}$ constitute a *Dynamic Tiebout Equilibrium* (DTE) if the following two conditions are met:

1. **Free Mobility (FM)**: Given the prices and politics, the allocation assigns every agent i who is born in any given period $t \in \mathcal{T}$, to his favorite jurisdiction. Formally, for $t = 1, \ldots, T-1$, for all $i \in \mathcal{I}$ where agent i chooses to live in jurisdiction j, it holds for all $\bar{j} \in \mathcal{J}$ that:
$$V(G_t^j) + \omega - p_t^j(G_t) - \frac{1}{L} g_t^j + \rho p_{t+1}^j(G_{t+1}) \geq V(G_t^{\bar{j}}) + \omega - p_t^{\bar{j}}(G_t) - \frac{1}{L} g_t^{\bar{j}} + \rho p_{t+1}^{\bar{j}}(G_{t+1}).$$
and for T and all $i \in \mathcal{I}$ where agent i chooses to live in jurisdiction j, it holds for all $\bar{j} \in \mathcal{J}$ that:
$$V(G_T^j) + \omega - p_T^j(G_T) - \frac{1}{L} g_T^j \geq V(G_T^{\bar{j}}) + \omega - p_T^{\bar{j}}(G_t) - \frac{1}{L} g_T^{\bar{j}}.$$

2. **Political Equilibrium (PE)**: Given the mapping of agents to jurisdictions and the price of housing, g_t^j arises as a political equilibrium. Formally, we require for $t = 1, \ldots, T-1$, for all $j \in \mathcal{J}$ and all $\bar{g}$,

$$\rho p_{t+1}^j(G_{t+1}) - \frac{g_t^j}{L} \geq \rho p_{t+1}^j(\delta(\bar{g} + G_t^j), G_{t+1}^{-j}) - \frac{\bar{g}}{L},$$

where $G_{t+1}^{-j} \equiv (G_{t+1}^1, \ldots, G_{t+1}^{j-1}, G_{t+1}^{j+1}, \ldots, G_{t+1}^J)$, and for T and all $j \in \mathcal{J}$, g_T^j is the lowest number that is feasible (either) 0 or $-G_T$.

Unfortunately, FM and PE are not sufficient to guarantee that all DTE are Pareto optimal. The next Lemma shows that in general, there will exist price systems that support many nonoptimal equilibria.

Lemma 2. *Consider any arbitrarily chosen steady-state level of DLPG, $\bar{G}$. Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed. Then there exists a price system* $\mathbf{p}$ *such that for all* $j \in \mathcal{J}$

$$\bar{g}_t^j = \begin{cases} \frac{\bar{G}-(1-\delta)G_1}{1-\delta} & t = 1 \\ \frac{\delta\bar{G}}{1-\delta} & t \in \mathcal{T}^O \\ -G_T^j = -\bar{G} & t = T \end{cases}$$

and $\mathbf{p}$ *supports this plan and satisfies FM and PE.*

For example, suppose the prices for houses were some large p if every jurisdiction builds a large freestanding, but zero otherwise.

Then all jurisdictions are incentivized to build one regards of whether it is an optimal DLPG investment.

In effect, any commonly held beliefs about the effect of public investment on land prices that respect the differences in the attractiveness between jurisdictions are a self-fulfilling prophecy.

We propose the following refinement on the set of equilibrium prices to remove these equilibria:

3. **Small Jurisdictions (SJ)**: Suppose for any $t \in \mathcal{T}$, G_t and $\bar{G}_t$ differ only in the amount of DLPG in single jurisdiction $j \in \mathcal{J}$. Then there exists a jurisdiction $\bar{j} \neq j$ such that $p_t^{\bar{j}}(G_t) = p_t^{\bar{j}}(\bar{G}_t)$.

This says that if any single jurisdiction changes its DLPG level, there is at least one other jurisdiction in which land prices are unaffected.

This refinement dramatically reduces the set of allocations that can be supported as DTE.

Under SJ we will also be able to prove First and Second Welfare Theorems.

We begin by characterizing of the set of DTE under SJ.

Theorem 3. *Let* $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ *and* $\mathbf{p}$ *be a DTE for an economy satisfying SJ. Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed. Then for all* $j \in \mathcal{J}, g_1^j = \frac{G_{ss}-(1-\delta)G_1}{1-\delta}$, $g_t^j = g_{ss} = \frac{\delta G_{ss}}{1-\delta}, G_t^j = G_{ss}$ *for* $t \in \mathcal{T}^O$, *and* $g_T^j = -G_T^j = -G_{ss}$.

In proving Theorem 3, we show that PE and FM imply the following key necessary condition for equilibrium prices for all $t \in \mathcal{T}$, and all $j \in \mathcal{J}$, which we refer to as the *relative price condition*:

$$p_t^j(G_t) - p_t^{\bar{j}}(G_t) = \left(V(G_t^j) - V(G_t^{\bar{j}})\right) + \frac{1}{L}\left(G_t^j - G_t^{\bar{j}}\right).$$

This shows that even if we included the entire history of DLPG levels in each period and every jurisdiction as arguments in the price function, the only thing that could have an effect on the differences in price between jurisdictions in any period t is the current state of DLPG. Thus, the relative price of jurisdictions in a given period depends only on the current state and is pinned by PE and FM.

Welfare Theorems without Nonnegativity Constraints

We can now show welfare theorems for DTE. Our first step is to show that the set of planner's solutions is identical to the set of Pareto optimal allocations.

Lemma 3. *Assume $G_{ss} \geq G_1$ and suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed. Then a feasible allocation,*$(\mathbf{c}, \mathbf{g},$ *is Pareto efficient if and only if it is also a solution to the planner's problem.*

Welfare Theorems without Nonnegativity Constraints

A First Welfare Theorem follows almost immediately.

Theorem 4. *(First Welfare Theorem) Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed. Then if* $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ *and* $\mathbf{p}$ *are a DTE for an economy satisfying SJ,*$(\mathbf{c}, \mathbf{g}, \mathbf{G})$ *must also be Pareto optimal.*

A Second Welfare Theorem also holds. In fact, it is possible to implement any equal treatment Pareto optimal allocation solely through the price system without redistributing endowments at all. By equal treatment we mean that agents in a given period get identical levels of private good, though this level may differ across periods. Formally,

4. **Equal Treatment in Private Goods (ET)**: A feasible allocation $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ satisfies ET if for all $t \in \mathcal{T}$, and all $i, \bar{i} \in \mathcal{I}, c^i_{t-1,t} = c^{\bar{i}}_{t-1,t} \equiv c_{t-1,t}$ and $c^i_{t,t} = c^{\bar{i}}_{t,t} \equiv c_{t,t}$.

Welfare Theorems without Nonnegativity Constraints

Theorem 5. *(Second Welfare Theorem) Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed and that a feasible allocation* $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ *is Pareto optimal and satisfies ET. Then there exists a price system* $\mathbf{p}$ *such that* $(\mathbf{c}, \mathbf{g}, \mathbf{G})$ *and* $\mathbf{p}$ *are a DTE.*

The Second Welfare Theorem is also a constructive proof that equilibrium exists.

The two Welfare Theorems together imply that DTE exists and is first best.

Tiebout's basic insight that if agents vote with their feet to choose tax/public good combinations, then the outcome will be first best carries over to overlapping generations economies with a DLPG. $\Longleftrightarrow$ A Dynamic Tiebout Theorem.

Optimality and Decentralization with Nonnegativity Constraints

Suppose that we instead maintained the nonnegativity constraints and also added the requirement that all prices be nonnegative in order to explore the implications for decentralizing the planner's solution. We begin with the following observation:

Observation 1. It is *never* possible to support an investment level higher than $g = \frac{1}{2}L\omega$ with prices in any jurisdiction for two consecutive periods.

An immediate implication of observation 1 is that, in general, we should not expect to be able to decentralize the planner's solution with prices if we do not allow them to be negative. At best, DLPG should accumulate at **something less than half the rate that would be socially optimal** in a free market equilibrium. This also means that the free market could never support a steady-state DLPG level such that $g_{ss} > \frac{1}{2}L\omega$.

Observation 2. Very high absolute price levels for housing can result in suboptimal investment in DLPG, even at a steady state.

In effect, high absolute prices can force all agents to invest less when young, and consume more in old age than is socially optimal.

If capital markets were perfect, agents could simply borrow from the future to set things right again, but this is not allowed in our model.

Thus, it is not only relative prices that must be set correctly to induce optimal behavior, but also absolute prices. A strong housing market might very well starve the public sector for funds.

Optimality and Decentralization with Nonnegativity Constraints

Observation 3. Very low absolute price levels for housing can also result in suboptimal investment in DLPG.

In this case, low absolute prices make it impossible to give young agents a sufficient incentive to invest optimally.

If capital markets were perfect, young agents could save optimally, but this would not solve the DLPG investment problem.

Even in the presence of perfect capital markets, there is nothing these unborn agents can do to incentivize an increase in investment before they exist.

Optimality and Decentralization with Nonnegativity Constraints

We have a kind of **Goldilocks situation**.

Prices can be too high or too low. If they are just right, then they may be able to support the optimal steady state.

We suspect that generally, that the "normal price" range for housing falls within this Goldilocks zone in most places

Optimality and Decentralization with Nonnegativity Constraints

Putting these observations together, we conclude that if we add the non-negativity constraints:

- DTE exist but may not always be Pareto optimal. (Unconditional Existence)

- We can support any socially optimal steady state DLPG level as a DTE if the steady state level of DLPG is not too high. (Conditional Second Welfare Theorem)

- Any interior DTE is socially optimal. (Conditional First Welfare theorem).

- The build up to the steady state will take longer in a DTE than a social optimum.

Centralization vs. Decentralization

We now compare the performance of centralized and decentralized institutions in the presence of intergenerational spillovers.

The model of centralization we use is a straightforward variation of the decentralized one outlined in previous sections.

The only difference is that the level of DLPG is chosen in a national election and is *identical* across jurisdictions.

Let G_t denote the common level of DLPG in each jurisdiction (note that agents have identical tastes).

Since the DLPG levels are the same in each jurisdiction (and thus, per capital investment is also the same) it is immediate that a price system $\mathbf{p}$ satisfies FM if and only if for all $t \in \mathcal{T}$, any $j, \bar{j} \in \mathcal{J}$, and any $G_t \in \Re^1_+$,

$$p_t^j(G_t, \ldots, G_t) = p_t^{\bar{j}}(G_t, \ldots, G_t).$$

The FM has no bite since we can never have price or DLPG level differences between jurisdictions within a given period.

The SJ assumption has no bite either for the same reason.

This implies that arbitrary sunspots can arise, and anything can be an DTE under centralization.

Theorem 6. *Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed but that agents vote in a central election over a common level investment for all jurisdictions each period. Consider an arbitrary path of DLPG levels for each period:* $(\bar{G}_2, \ldots, \bar{G}_T) \in \Re_+^{T-1}$ *(not necessarily a steady state). Then there exists a price system* $\mathbf{p}$ *that satisfies PE, FM which supports this path.*

Notice that sunspots can arise if local land prices depend on the national level of DLPG. But why should this be so?

The only economic force behind these sunspots are self-fulfilling beliefs.

Since the plots of land are identical in every jurisdiction *and* DLPG levels are also identical by assumption, it might make sense to remove the dependence of land prices on centrally provided DLPG.

5. **No Sunspots (NS)**: For all $t \in \mathcal{T}$, all $j \in \mathcal{J}$, and all $G_t \in \Re^1_+$, prices take the form: $p_t^j(G_t, \ldots, G_t) = K_t$.

The next Theorem shows that although the no-sunspot refinement gets rid of the problem of multiple equilibria, the one that remains is inefficient.

Theorem 7. *Suppose that the nonnegativity constraints on DLPG investments and private good consumption are removed but that agents vote in a central election over common level investment for all jurisdictions each period. Then any price system* $\mathbf{p}$ *that satisfies PE, FM and NS results in zero provision of DLPG in each period.*

Conclusion

We conclude that there is an essential trade-off:

1. Intergenerational spillovers are internalized by competing jurisdictions through capitalization, but selfish agents in this case ignore all interjurisdictional spillovers.

2. Interjurisdictional spillovers are internalized when agents vote centrally over public goods levels, but since there are no competitive forces that capitalize future benefits into land values, intergenerational spillovers are ignored with national decision-making.

Thus:

Conclusion

A. Let goods that are **durable** and **local** be provided by jurisdictions (roads, local infrastructure). This is because of heterogeneous tastes and intergenerational spillovers.

B. Good that are **nondurable** and **local** should be provided by jurisdictions (fireworks, services). This because of heterogeneous tastes only.

C. Let goods with are **nondurable** and **purely public** be provided nationally (medical care). This is because of interjurisdictional spillovers only

D. Goods that are **durable** and **purely public** can't be provided well anywhere (defense, education, environmental protection). This is because of the conflict between internalizing intergenerational and interjurisdictional spillovers.

Conclusion

Our main conclusion is that in this capitalization is indeed an effective mechanism to cause agents to internalize intergenerational spillovers.

This is limited to the degree that there are more general spillovers across jurisdictions.

A full Dynamic Tiebout Theorem holds when there are no nonnegativity constraints.

A limited Dynamic Tiebout Theorem holds when there are negativity constraints.

We believe that this is important because there are many papers which study models with distortions (for example, uncertainties, incomplete information, and market power).

Unless we have a baseline case of a competitive economy for which a first welfare theorem applies, however, it is hard to know if the inefficiencies in these models come from the distortions in question or are a result of the underlying economic structure