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A Test for Allocative Efficiency in the Local Public Sector

Jan K. Brueckner, Associate Professor
Department of Economics

Abstract

This paper develops a test for Pareto-efficiency in the local public sector which is based on the analytical result that aggregate property value is maximized at the public output level where the Samuelson condition for efficiency is satisfied. By using cross-section data, it is possible to deduce whether a representative community provides its public goods in a property-value-maximizing (and hence efficient) fashion. The empirical results show no systematic tendency to either under- or overprovide public goods in a sample of Massachusetts communities.

A Test for Allocative Efficiency in the Local Public Sector

by

Jan K. Brueckner

The issue of allocative efficiency in the provision of public goods has been a central concern of theoretical work in public finance ever since the pioneering work of Samuelson (1954). The positive question of whether resource allocation in the public sector is in fact efficient in the real world has, however, received much less attention. In a rare attempt to address this question, Barlow (1970) concluded that education services were overprovided in his sample by using an ingenious argument which invoked the median voter model and required only a few pieces of data. The present paper is designed to address the efficiency question in an entirely new fashion. The paper's empirical test is based on the recently-discovered result (see Brueckner (1979b, 1980)) that, other things equal, aggregate property value in a community which levies an *ad valorem* property tax is an inverted-U-shaped function of its public good output, with the maximum occurring at the level where the Samuelson condition for Pareto-efficiency is satisfied. Using this result, it follows that if aggregate property value in a community is insensitive, *ceteris paribus*, to a marginal change in its public good output, then the good is a provided at a Pareto-efficient level. The test for efficiency developed below makes use of cross-section regression results showing the relation between aggregate property values, public expenditures, and other variables for a sample of Massachusetts communities. By proper interpretation of these results, the response of aggregate

property value in a representative community to a change in its public good output may be inferred, allowing an appraisal of efficiency. The present test represents an improvement over a related, more complex, test carried out by Brueckner (1979b), which was based on a regression equation using median instead of aggregate property value as the dependent variable.

It is important to realize that the intent of this paper is not to test the Tiebout hypothesis (1956). That hypothesis, which predicts that consumers will stratify into (necessarily efficient) homogeneous communities, has been largely discredited in recent theoretical studies (see, for example, Stiglitz (1977) and Brueckner (1979a)). The following analysis implicitly acknowledges this negative verdict on Tiebout by portraying an economy where communities are realistically heterogeneous. The question addressed is whether such communities manage, in spite of their heterogeneity, to provide public goods efficiently.

Before beginning the analysis, it must be acknowledged that the present paper owes an obvious debt to the seminal work of Oates (1969), who first discovered an empirical relationship between property values and local public spending (his interpretation of this discovery was, however, inadequate in light of present knowledge). Also, it should be noted that theoretical results on the relation between property values and efficiency derived by Sonstelie and Portney (1978) are similar in many ways to those which underlie the present study. In the next section of the paper, a theoretical model of property value determination under ad valorem property taxation is developed and the relationship between property values and public outputs is derived. Subsequent

sections of the paper describe the estimation problem and present the empirical results and final conclusions.

1. Analysis

The first assumption underlying the analysis is that consumers have identical tastes. While this requirement is somewhat unrealistic, no empirical study of the relation between property values and public spending can proceed without it. Utility is assumed to depend on the consumption of four commodities: housing services (q), two public goods (z_1 and z_2), and a numeraire composite commodity (x). It is assumed that the common utility function $u(z_1,z_2,q,x)$ is strictly quasi-concave. Two public goods are included in the model for realism; in the empirical work, the public goods are education and a composite of municipal services such as fire and police protection.

A further strong assumption is that utility is uniform across the system of communities under consideration for the members of each income group. Letting $\bar{u}$ denote the utility level achieved by an individual in equilibrium, this assumption means that $\bar{u} = h(y)$, where y is the individual's income and h is some function. Although the equilibrium relationship between utility and income is not explained with the model, the assumption $h' > 0$ (wealthier people reach higher utilities) is natural. Uniform utilities require the absence of market frictions: a consumer is free to move to another community or to change his assumption bundle within a given community if doing so increases his utility.

The first step in the analysis is to determine house rent as a function of the public good levels, house size, and the income of the

occupant. It must be stressed that the analysis does not explore the consumer's choice of q and x for given public consumption levels. Instead, the argument proceeds in reverse by asking what the rent on a house must be in order for its occupant to enjoy the utility level which he is assumed to reach in equilibrium. Since utility must equal h(y), it follows that the equilibrium consumption bundle for a consumer with income y must satisfy

$$h(y) = u(z_1,z_2,q,x) \tag{1}$$

Inverting this equation yields

$$x = \tilde{u}(z_1,z_2,q,h(y)) \equiv t(z_1,z_2,q;y), \tag{2}$$

which gives the amount of x required to generate utility h(y) for an individual with specified housing and public good consumption levels. Letting R denote house rent, it follows that for the individual to be able to purchase the amount of x given by (2), the relation

$$y - R = t(z_1,z_2,q;y) \tag{3}$$

must hold. Rearrangement yields the consumer "bid-rent" function, which relates rent to public consumption levels, house size, and income:

$$R(z_1,z_2,q;y) \equiv y - t(z_1,z_2,q;y). \tag{4}$$

It follows from (1) and (3) that $R_1 = u_1/u_4 > 0$, $R_2 = u_2/u_4 > 0$, $R_3 = u_3/u_4 > 0$, and $R_4 = 1\text{-}h'/u_4 \gtrless 0$ (subscripts indicate partial derivatives). The positive signs of R_1, R_2, and R_3 result from the fact that a higher z_1, z_2, or q requires a lower x and hence higher rent to keep

utility constant (utility is constant since y is fixed). The sign of R_4 is indeterminate because of two opposing effects. First, holding z_1, z_2 and q fixed, the increase in utility which accompanies an increase in income requires an increase in x. Therefore rent, which is the difference between y and x, can either increase or decrease since y itself increases. Finally, it is easy to show that the strict quasi-concavity of the utility function u means that R is a strictly concave function of z_1, z_2, and q.

It is important to realize that a normal consumer choice process occurs behind the scenes in the present model; consumers choose housing and x consumption to maximize utility subject to a budget constraint in standard fashion. Thus, although (4) gives the rent consistent with a consumer's equilibrium utility level in houses of all sizes, the rental payment actually made by the consumer (for given z_1 and z_2) is found by substituting in (4) his chosen value of q. Now since this value will depend on z_1, z_2, and y (we would expect q to increase with y), it follows that the arguments of R cannot be viewed as independent of one another. The crucial observation, however, is that regardless of the extent of correlation among z_1, z_2, q, and y, house rent must be related to these variables in the manner described by (4).[1]

The next important assumption is that tax revenue is raised entirely by ad valorem property taxation using separate property tax rates τ_1 and τ_2 for the two public goods. This assumption is faithful to reality for the chosen sample since Massachusetts communities levy no sales or income taxes. Now the value (or selling price) of a rental property equals the present discounted value of the excess of rent over the property tax liability. Letting v represent value, it follows that

$$v = \frac{R-(\tau_1+\tau_2)v}{\theta}, \tag{5}$$

where θ is the discount rate.[2] Rearrangement gives the value of a house as a function of z_1, z_2, q, y, and the property tax rates:

$$v = \frac{R(z_1,z_2,q;y)}{\theta+\tau_1+\tau_2}. \tag{6}$$

Using (6), the aggregate value of rental property in a community may be written

$$\frac{\Sigma R(z_1,z_2,q_i;y_i)}{\theta+\tau_1+\tau_2}. \tag{7}$$

Although the discussion so far applies to rental houses, the same results hold with owner-occupied dwellings. This follows because in equilibrium, an owner-occupier must be indifferent between owning and renting his house. Indifference requires that the present discounted value of rental payments R/θ equals the purchase price of the house v plus the present discounted value of property tax payments $(\tau_1+\tau_2)v/\theta$. This equality reduces to (5), implying that (7) is appropriate regardless of the renter-owner-occupier composition of the community.[3]

A variant of the preceding discussion applies to business property. Suppose first that production uses labor as well as structure and non-structure capital but that the public goods z_1 and z_2 do not enter firm production functions. For a given structure input s, firms (which are assumed to be identical) will maximize profit gross of rent, with the maximized value $\pi(s,g)$ depending on the structure input and the wage rate g (the price of non-structure capital (machines and intermediate goods) will be uniform across communities). Since business rents will

be bid up to eliminate profits, the rent for a business structure of size s in a community with wage rate g must equal $\pi(s,g)$. The value of a business structure is consequently $\pi(s,g)/(\theta+\tau_1+\tau_2)$, with aggregate business property value in a community being given by[4]

$$\frac{\Sigma\pi(s_i,g)}{\theta+\tau_1+\tau_2} \equiv \frac{\Pi}{\theta+\tau_1+\tau_2} \quad . \tag{8}$$

Using (7) and (8), aggregate business and residential property value may be written

$$\frac{W(z_1,z_2,Q;Y) + \Pi}{\theta+\tau_1+\tau_2} \equiv P, \tag{9}$$

where the function W represents $\Sigma R(z_1,z_2,q_i;y_i)$ from (7) (Q and Y are the vectors of the q_i and y_i respectively).

The property tax system must raise revenue sufficient to finance that part of a community's public expenditures not supported by intergovernmental aid. Letting G_i denote the intergovernmental revenue received by the community to help finance provision of public good i, budget balance for the local government requires

$$\frac{\tau_1(W+\Pi)}{\theta+\tau_1+\tau_2} + G_1 = C^1(z_1,n) \tag{10}$$

$$\frac{\tau_2(W+\Pi)}{\theta+\tau_1+\tau_2} + G_2 = C^2(z_2,n), \tag{11}$$

where the C^i are the cost functions for public production. The appearance of community population n in these functions reflects public good congestion; $C_2^i \equiv 0$ is appropriate if z_i is a pure public good, while $C_2^i > 0$ would hold in the presence of congestion.[5] Note that the first terms in (10) and (11) represent the revenue generated by the two property tax levies.

Equations (10) and (11) constitute a two-equation system which determines τ_1 and τ_2 as functions of z_1, z_2, Q, Y, Π, G_1, and G_2 (n is implicit in the dimension of the vectors Q and Y). Substitution in (9) reduces aggregate property value to an expression which depends only on the above variables:

$$P = P(z_1, z_2, Q, Y, \Pi, G_1, G_2). \qquad (12)$$

By using (10) to evaluate the partial derivatives of τ_1 and τ_2 with respect to the given variables, the partial derivatives of P in (12) may be computed. Lengthy but straightforward calculations yield

$$\frac{\partial P}{\partial \Pi} = \frac{1}{\theta+\tau_1+\tau_2} - \frac{W+\Pi}{(\theta+\tau_1+\tau_2)^2}\left(\frac{\partial \tau_1}{\partial \Pi} + \frac{\partial \tau_2}{\partial \Pi}\right) = \frac{1}{\theta} > 0 \qquad (13)$$

$$\frac{\partial P}{\partial G_i} = - \frac{W+\Pi}{(\theta+\tau_1+\tau_2)^2}\left(\frac{\partial \tau_1}{\partial G_i} + \frac{\partial \tau_2}{\partial G_i}\right) = \frac{1}{\theta} > 0, \ i = 1,2 \qquad (14)$$

$$\frac{\partial P}{\partial Q} = \frac{\partial W/\partial Q}{\theta+\tau_1+\tau_2} - \frac{W+\Pi}{(\theta+\tau_1+\tau_2)^2}\left(\frac{\partial \tau_1}{\partial Q} + \frac{\partial \tau_2}{\partial Q}\right) = \frac{1}{\theta}\frac{\partial W}{\partial Q} > 0. \qquad (15)$$

(Note that $\partial P/\partial Q$ is a vector with representative element $\partial P/\partial q_k$ = $(1/\theta)(\partial W/\partial q_k) \equiv (1/\theta)\ R_3(z_1,z_2,q_k;y_k)$.) Now the partial derivatives of the τ_i with respect to Π, Q and the G_i are all negative due to the reduction in tax effort which is possible in a community with large houses, substantial business property, or generous intergovernmental aid. An increase in Q or Π therefore causes a direct increase in aggregate value via an increase aggregate rent together with an indirect increase due to lower tax rates, leading to the positive expressions in

(13) and (15). While an increase in G_i has no direct effect on rent, the indirect effect which operates through lower tax rates increases aggregate value.

Although an increase in Π could reflect an increase in either the size or number of business properties, the derivative $\partial P/\partial Q$ implicitly holds the number of residential dwellings fixed. Finding the effect on value of an increase in the size of the housing stock requires further analysis. First, it is easy to see that if z_1 and z_2 are pure public goods ($C_2^1 \equiv C_2^2 \equiv 0$), then any increase in the housing stock (an increase in the dimension of the vectors Q and Y, with arbitrary q and y values added) permits lower tax rates. Thus the positive direct effect of a larger housing stock on aggregate value is reinforced by a positive indirect effect due to lower tax rates, and value increases. On the other hand, if the public goods are congested then higher expenditures are needed to hold the z_i fixed as n increases, and the directions of the required budget-balancing tax rate changes are uncertain, leading to an indeterminate change in aggregate value. Brueckner (1981) recently provided evidence that the congestion properties of municipal fire protection are close to those of a pure public good. To the extent that this property is shared by other public goods, a larger housing stock will mean higher aggregate property value.

The effect of an increase in income on aggregate property value holding the housing stock and other variables fixed is similarly ambiguous. This indeterminacy is a result of the ambiguous sign of the partial derivative of R with respect to y, which makes the influence of y on aggregate rent and on the property tax rates impossible to evaluate (see above).

The nature of the relationship between aggregate property value and the levels of the public goods z_1 and z_2 provides the basis of the test for allocative efficiency developed below. Calculations similar to those underlying (13)-(15) yield

$$\frac{\partial P}{\partial z_\ell} = \frac{\partial W/\partial z_\ell}{\theta+\tau_1+\tau_2} - \frac{W+\Pi}{(\theta+\tau_1+\tau_2)^2}\left(\frac{\partial \tau_1}{\partial z_\ell} + \frac{\partial \tau_2}{\partial z_\ell}\right) = \frac{1}{\theta}\left(\frac{\partial W}{\partial z_\ell} - C_1^\ell\right)$$

$$\equiv \frac{1}{\theta}\left(\sum_i R_\ell(z_1,z_2,q_i;y_i)-C_1^\ell\right) \qquad (16)$$

$$\equiv \frac{1}{\theta}\left(\sum_i \frac{u_\ell(z_1,z_2,q_i,x_i)}{u_4(z_1,z_2,q_i,x_i)} - C_1^\ell\right), \quad \ell = 1,2$$

where the last equality follows from the definition of the function R (see above).[6] Equation (16) establishes that $\partial P/\partial z_1$ and $\partial P/\partial z_2$ both equal zero when z_1 and z_2 assume values such that for each public good, the sum of the marginal rates of substitution between that good and the numeraire equals the good's marginal cost (that is, where both Samuelson conditions hold). Moreover, it is easy to show that as long as the public goods are produced with constant or decreasing returns ($C_{11}^\ell \geq 0$, $\ell=1,2$), aggregate property value is a strictly concave function of z_1 and z_2.[7] The concavity of P means that, holding the stock of structures and consumer income (and hence utility) levels fixed, aggregate property value reaches a global maximum at values of z_1 and z_2 where the Samuelson conditions hold. This important result provides the foundation for the subsequent empirical work.

By imposing more structure on consumer tastes, it becomes possible to deduce whether the public goods exceed or fall short of their (*ceteris paribus*) property-value-maximizing levels simply by examining the signs of $\partial P/\partial z_\ell$, $\ell=1,2$. This greatly simplifies interpretation of later empirical results. It is necessary to assume that the utility function is additively separable in z_1 and z_2, so that $u(z_1,z_2,q,x) \equiv \phi(z_1,q,x) + \gamma(z_2,q,x)$. In this case, the MRS between z_1 and x is independent of z_2 and the MRS between z_2 and x is independent of z_1, with the result that $\partial P/\partial z_\ell$ in (16) depends only on z_ℓ, $\ell=1,2$. This in turn means that z_ℓ is $\left\{\begin{matrix}\text{underprovided}\\ \text{overprovided}\end{matrix}\right\}$ relative to the property-value-maximizing level as $\partial P/\partial z_\ell \gtrless 0$, $\ell = 1,2$. Without separability of tastes, this useful conclusion need not follow.

Suppose that the equalities $\partial P/\partial z_1 = \partial P/\partial z_2 = 0$ are satisfied for a given community. In other words, suppose that holding the stocks of residential and business structures, intergovernmental aid levels, and consumer income (and utility) levels fixed, a marginal increase in the level of either public good would leave aggregate property value unchanged, implying that aggregate value is maximal. Although (16) shows that the local stationarity of aggregate value necessary for a maximum requires satisfaction of the familiar Samuelson conditions, it is important to know precisely what efficiency implications stationarity holds. The issue is, unfortunately, not entirely straightforward due to the existence of an *ad valorem* property tax. As shown in Brueckner (1980) using a model without business property, such a tax will distort consumer choice between housing and the numeraire x, leading to an equilibrium in which the housing stock must be viewed as non-optimal. As a

result, satisfaction of the Samuelson conditions yields only a second-best conclusion in a model with $\Pi = 0$: under ad valorem property taxation, satisfaction of these conditions implies that resource allocation within the community is Pareto-efficient conditional on the non-optimal housing stock (see Brueckner (1980)). Thus, when aggregate property value is locally stationary (and hence maximal) with respect to variation in z_1 and z_2 in the present model, it follows that holding the stock of residential and business structures fixed, no rearrangement of (nonstructure) community resources can lead to a Pareto-superior allocation.[8]

Now it is important to realize that varying z_1 and z_2 while holding Q, Y, Π, and the G_i fixed is a purely conceptual exercise. Since the variables determining aggregate value are highly interdependent, an alteration in z_1 or z_2 holding the remaining variables fixed does not represent a conceivable real-world change. The goal of the empirical work, however, is to deduce the ceteris paribus effects on aggregate value of changes in the z_i by using data from a cross-section of communities. The feasibility of such an approach, whose ultimate goal is to reach an efficiency verdict for communities in the sample, is made clear in the next section.

2. The Estimation Problem

Sample observations for the variables P, z_1, z_2, Q, Y, Π, G_1, and G_2 will lie somewhere on or near the aggregate property value hypersurface defined by (12) (a random error term will account for some scatter around the hypersurface). The goal of the empirical work is to

extract information from this point scatter concerning public sector efficiency in the sample. To see how this is possible, consider for a moment an unrealistic situation in which a single public good z is provided at different levels in a cross-section of communities with identical values of Q, Y, Π, and C (note that C_1 and C_2 have become one variable). In this case, aggregate property value is a simple single-peaked function of z, as shown in Figure 1. Suppose further that as shown in the Figure, all sample observations lie to the left of the peak (that is, $\partial P/\partial z > 0$ holds in each community). This means that the public good outputs in the sample are inefficient in the conditional sense of Section 1 (holding a community's stock of structures fixed, a higher public good output would permit a Pareto-superior allocation). Now in the situation shown in the Figure, it is clear that a regression line fitted to the data will exhibit a positive slope. Similarly, if all observations lie to the right of the peak (public goods are overprovided relative to the common (conditionally) efficient level), then the regression line will have a negative slope, while if observations are clustered near the peak of the curve, then the slope will be near zero. When communities realistically have different values of Q, Y, Π, and C, similar conclusions emerge: if communities uniformly satisfy $\partial P/\partial z \gtreqless 0$, then a regression hyperplane fitted to the data will exhibit a $\begin{Bmatrix}\text{positive}\\ \text{zero}\\ \text{negative}\end{Bmatrix}$ z-coefficient. Similarly, when two public goods are provided, uniform satisfaction of $\partial P/\partial z_i \gtreqless 0$ yields a $\begin{Bmatrix}\text{positive}\\ \text{zero}\\ \text{negative}\end{Bmatrix}$ z_i-coefficient for a regression plane, i = 1,2. If one is willing to

believe that communities share a common efficiency bias in providing public goods (uniformly underproviding or overproviding them relative to the (community-specific) levels where $\partial P/\partial z_i = 0$), then the preceding discussion makes interpreting property value regression results especially easy. In the one-public-good case, a $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ z-coefficient will indicate a common bias toward $\left\{\begin{matrix}\text{underprovision}\\ \text{overprovision}\end{matrix}\right\}$ of the good, while a zero coefficient will indicate a tendency toward efficient provision. Similar conclusions hold in the case of two public goods when it is recalled that separability of tastes allows the direction of inefficiency for good z_i to be evaluated simply by noting the sign of $\partial P/\partial z_i$, $i = 1,2$. With separable tastes, a $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ z_i-coefficient will indicate a common bias toward $\left\{\begin{matrix}\text{underprovision}\\ \text{overprovision}\end{matrix}\right\}$ of good z_i, $i = 1,2$, while a zero coefficient will indicate a tendency toward efficient provision of the good.

The preceding argument shows that when communities exhibit a common efficiency bias, the direction of inefficiency in the sample may be evaluated by simply noting the signs of the z_i-coefficients of a regression plane fitted to the data. Without a common bias, however, interpretation of regression results is more difficult. For example, if some communities substantially underprovide while others substantially overprovide public goods, then in the simple case of Figure 1, data points will be clustered in two widely-separated groups on either side of the peak of the curve and a regression line may show a slope close to zero. In this case, a zero slope indicates a diversity of public good levels rather than a tendency toward efficiency. This type of ambiguity, however, does not prohibit the extraction of important information from

regression results. Since a positive z_i-coefficient is inconsistent with uniform overprovision of good z_i in the sample, while a negative coefficient is inconsistent with uniform underprovision, it follows that a $\left\{\begin{matrix}\text{positive}\\\text{negative}\end{matrix}\right\}$ z_i-coefficient is evidence <u>against</u> a systematic tendency to $\left\{\begin{matrix}\text{overprovide}\\\text{underprovide}\end{matrix}\right\}$ good z_i. For example, a positive z_1-coefficient justifies the statement "not all communities in the sample are overproviding z_1." While this statement is weaker than the conclusion that z_1 is uniformly underprovided, it does not rely on the strong assumption of a common efficiency bias among communities. Finally, a zero z_i-coefficient is evidence that there is no systematic tendency to underprovide <u>or</u> overprovide good z_i. It is, of course, not possible to tell in this case whether public good levels are approximately efficient in the sample or whether (as in the above example) communities choose grossly inefficient outputs.

The next section of the paper describes the estimation procedure and the data and interprets the empirical results in light of the preceding discussion.

3. Estimation Technique, Data, and Empirical Results

In fitting a regression plane to the data, the fact that the aggregate property value relationship (12) forms part of a simultaneous equation system was taken into account. First, as discussed above, the features of a community's housing stock will depend on the income levels of its residents as well as on features of the economic environment such as the levels of z_1 and z_2. Moreover, since a community's public good outputs represent the outcome of a political process which aggregates

in some way the desires of its residents, z_1 and z_2 must themselves be viewed as functions of income levels, other socioeconomic variables, and variables such as Π, G_1, and G_2 which determine the tax effort required to support given expenditure levels. In addition, since intergovernmental aid of various types is determined in the sample by a number of complicated formulas involving local spending levels, incomes, and even aggregate property values (the latter applies in the case of state aid to education), it follows that G_1 and G_2 must be viewed as functions of other variables in the model.

Now as is well-known, the right-hand variables in an equation which is part of a simultaneous system will be correlated with the error term. In the present context, this means that the direction of sample deviations away from the hypersurface (12) will be sensitive on average to the values of the right-hand variables. In a standard simultaneous equations setting, this kind of correlation leads to inconsistent OLS estimates of structural parameters. As the discussion in Section 2 makes clear, however, the goal of the present empirical work is <u>not</u> to estimate the parameters of a structural equation. Rather, the empirical procedure is meant to indicate <u>where</u> on the hypersurface corresponding to the structural equation (12) the sample observations lie. Nevertheless, it is clear that correlation between the right-hand variables in (12) and the error term will distort the relationship between the point scatter and the underlying hypersurface, introducing a possible source of error into the procedure described in Section 2. To eliminate this correlation problem, two-stage least squares was used in fitting a regression plane to the data. The levels of the public goods and

intergovernmental aid as well as community housing characteristics were viewed as endogenous variables, while incomes, community size, and business profit gross of rent (which was viewed as closely related to local business employment) were taken to be exogenous.

As a result of the notorious unreliability of previous data on aggregate property values in Massachusetts communities, the state government completed in 1976 a costly, ambitious project designed to facilitate accurate measurement of aggregate values and thus increase the fairness of the distribution of state aid to education, which is tied in Massachusetts (as elsewhere) to the size of community tax bases. The resulting 1976 aggregate property value ("equalized value") measure is the dependent variable for the regressions. To represent the income vector Y, the scalar variable equal to community median income for 1970 (denoted YMED) was used (an income measure for a year closer to 1976 was not available). The search for variables measuring housing stock characteristics ranged over six possibilities: the percentage of 1970 housing units which had at least three bedrooms, had more than one bathroom, lacked some or all plumbing facilities, were in one-unit structures, or were built after 1960, and the median number of rooms in all housing units. Since only the second of these variables (denoted BATHS) performed as anticipated, it is the sole housing characteristics variable included in the regressions. As a measure of the size of the housing stock, the number of housing units in the community in 1970 (denoted HUNITS) was used (a more current housing stock proxy, 1975 community population, performed in an essentially identical fashion). At first, total retail, wholesale, service, and manufacturing employment

represented Π, business profit gross of rent. High correlation between HUNITS and total employment in the three non-manufacturing categories led to their deletion, however, with manufacturing employment (MFGEMP) remaining in the equation. As a result, the sizes of the stocks of residential and commercial structures are represented simultaneously by the variable HUNITS, with MFGEMP representing the stock of manufacturing structures. Although the model was developed with two intergovernmental aid variables, G_1 and G_2, it was felt that the regression procedure would not allow the untangling of separate aid effects. Consequently, a single aid variable, total intergovernmental revenue received by the community in 1976 (IGREV), appeared in the regressions. Although the model was developed without considering the effect of accessibility to employment on property values, a dummy variable representing community location was included in the regressions. The variable (LOCD), which assumes the value of zero for Boston and its seven innermost suburbs and equals unity otherwise, should exhibit a negative coefficient due to the positive relationship between accessibility and property values predicted by urban spatial analysis.

The greatest virtue of the Massachusetts sample is that school districts in the state are coterminous with municipalities and townships, guaranteeing that consumption of education and other municipal services is uniform within city boundaries. Almost everywhere else in the U.S., municipal and school district boundaries bear no systematic relationship to one another, making it exceptionally difficult to deduce the public spending levels relevant to any given area.[9] The public good levels z_1 and z_2 were represented by 1976 community education expenditures (EDEX)

and non-education municipal expenditures (MUEX). Both variables were computed net of capital outlays and reflect subtraction of charges for school lunches in the case of education and charges for sewage, hospital, and other services in the case of municipal expenditures (charges are levied for services not supported by property taxation).[10]

In the TSLS estimation procedure, the variables BATHS, IGREV, EDEX, and MUEX were taken to be endogenous, while YMED, HUNITS, MFGEMP, and LOCD were treated as exogenous. Other exogenous variables not in the equation but appearing in the reduced form were 1970 values for the percent of community residents with at least a high school education, the percent of families with children under six years of age, the percent of employed residents with white collar jobs, the percent of community housing units owner-occupied, the percent of units built since 1960 (a measure of the newness of the community), and a dummy variable which assumes the value one for a rural township and zero otherwise. Together with the included exogenous variables, these variables explain nearly all of the variance in the endogenous variables (reduced-form results are not reported).

The sample consisted of 54 communities in Massachusetts with school districts enrolling at least 5000 pupils in 1976. Fourteen communities with enrollments exceeding 5000 were not included in the sample because of non-negligible 1970 payments (in all cases in excess of 3% of education expenditures) to regional school systems for services such as secondary or vocational education (a number of regional school districts exist in Massachusetts to provide specialized services to small local districts).[11] A list of communities in the sample is found in the appendix.

The first line of Table 1 shows the TSLS regression results using EDEX, MUEX, HUNITS, BATHS, MFGEMP, YMED, IGREV, and LOCD as right-hand variables. Note that the estimated coefficient of BATHS is significantly positive, indicating that other things equal, a higher proportion of large houses (houses with more than one bathroom) leads to higher aggregate property value. Similarly, the significantly positive coefficient of HUNITS indicates that a larger number of housing units (and thus a larger stock of commercial structures) leads, other things equal, to higher aggregate value. The coefficient of MFGEMP is positive but insignificant, showing that the effect of manufacturing structures on aggregate value is too weak to manifest itself in the regressions. The coefficient of the location dummy LOCD has the anticipated negative sign, although the location effect on aggregate value is apparently not strong enough to yield an estimate significantly different from zero. YMED's coefficient is significantly negative, indicating that, other things equal, higher incomes reduce property values. Recall that the analysis yielded no definite sign prediction for this coefficient. While insignificant, the estimated coefficient of IGREV is negative and has a relatively large absolute t-ratio, in apparent violation of the model. The only immediate explanation for this anomaly is that the regression is picking up the negative relationship between state aid to education and aggregate (equalized) property value which follows from the state aid formula. In other words, the negative association between these variables implied by another structural equation in the system (the aid formula) is strong enough to mask, in spite of the use of TSLS, the positive relationship anticipated for the given structural equation.

The most important regression results, of course, are the estimated coefficients of EDEX and MUEX, neither of which is significantly different from zero. Recalling the discussion in Section 2, these facts justify the important conclusion that neither public good is systematically over- or underprovided in the Massachusetts sample. Under the supposition that communities share a common efficiency bias, the results carry the stronger implication that local public outputs in Massachusetts exhibit a tendency toward efficiency. The second line of Table 1 shows that similar conclusions emerge when communities are viewed as providing one public good instead of two. When public expenditure is represented by the single variable EX ≡ EDEX + MUEX, little change occurs in the sign and significance of the other estimated coefficients (one encouraging change is the substantial increase in MFGEMP's t-ratio). Moreover, EX's insignificant coefficient justifies the same efficiency conclusions reached above: there is no evidence of a tendency toward systematic over- or underprovision of a composite public good; evidence exists of a tendency toward efficiency under the assumption of a common efficiency bias.

It is interesting to note that using regression results based on median instead of aggregate property value, Brueckner (1979b) constructed a complex argument leading to the conclusion that public goods in the well-known Oates (1969) sample are overprovided. This conclusion relied on the assumption of a common efficiency bias.

4. Conclusion

The results in this paper show that Massachusetts communities exhibit no systematic tendency to over- or underprovide public goods.

This means that a representative community is as likely to provide each public good above the level which is Pareto-efficient conditional on its stock of structures as it is to provide it below the conditionally efficient level. If the strong assumption that communities share a common efficiency bias is satisfied, the results justify the stronger conclusion that the local public sector in Massachusetts exhibits a tendency toward conditional Pareto-efficiency. While similarity of governmental structures among communities in the sample suggests that a common efficiency bias may well exist, the assumption unfortunately remains in the realm of conjecture.

Although the above empirical results are informative and interesting, the paper's most important contribution is its demonstration that the public sector efficiency question can be addressed empirically using a unified, rigorous framework built on relatively weak assumptions. The other major efficiency study by Barlow (1970) does not share the latter feature since it invokes the median voter model and imposes strong assumptions on functional forms.

As a final observation, it should be realized that the passage in 1980 of Proposition 2 1/2, whose intent was to slash property tax levies in Massachusetts, appears puzzling in light of the present evidence. Apparently, a substantial majority of Massachusetts taxpayers desired a reduction in local public spending, suggesting that public outputs were generally above Pareto-efficient levels. Of course, voters may have subscribed to the common "tax revolt" notion that reduced government waste would allow maintenance of public consumption levels in the face of smaller budgets. To the extent that this notion was widely held, the passage of Proposition 2 1/2 is not inconsistent with this paper's empirical conclusions.

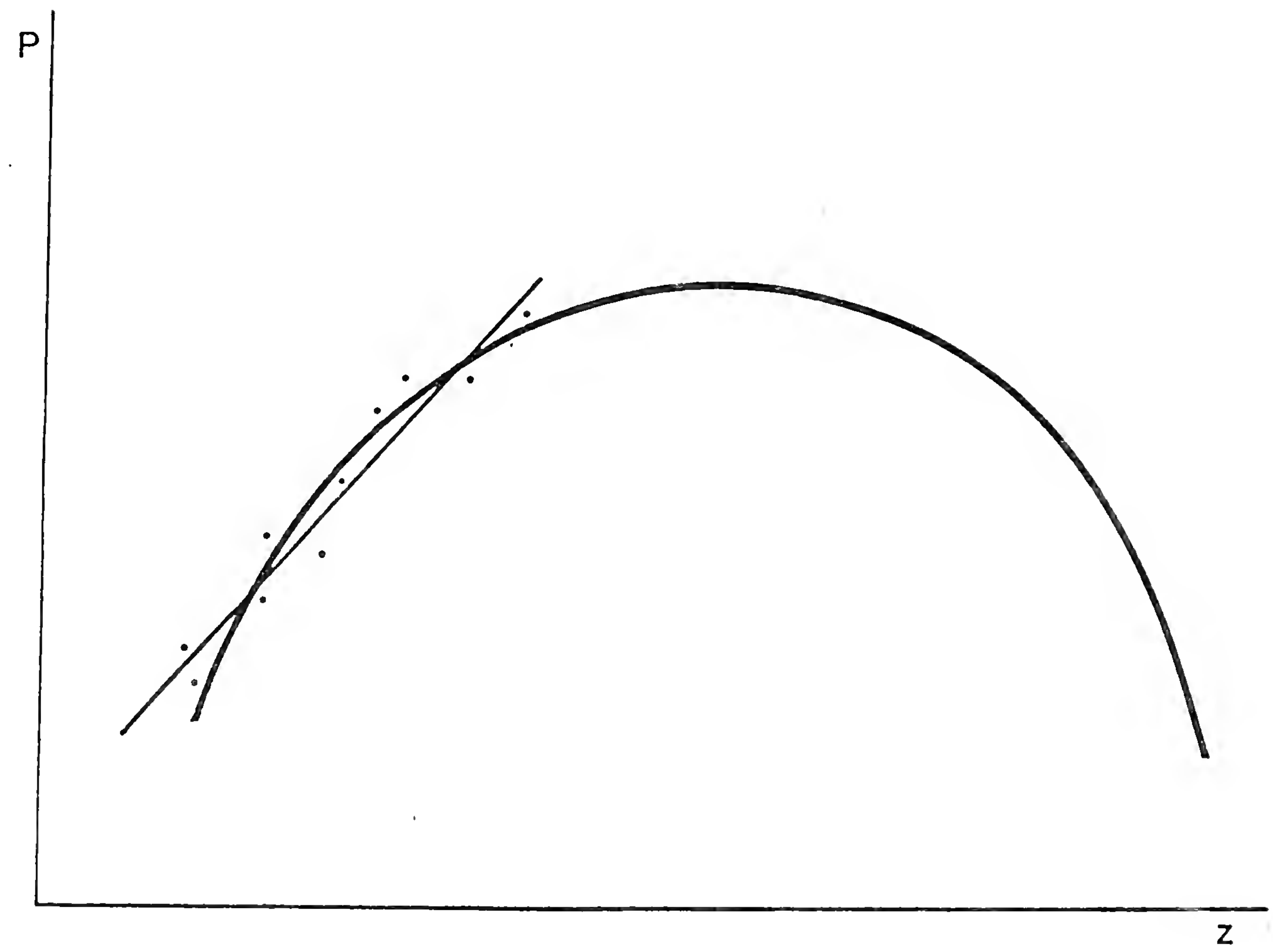

Figure 1.

Table 1

Estimated Coefficients

Constant	EDEX	MUEX	EX	HUNITS	BATHS	MFGEMP	YMED	IGREV	LOCD	R^2
5.44E05* (2.28)	2.17E01 (1.19)	-0.92E00 (-0.19)	--	1.50E01** (2.01)	1.43E04* (2.23)	2.68E00 (0.49)	-6.66E01* (-2.26)	-1.95E01 (-1.88)	-7.22E04 (-1.05)	.9669
5.48E05 (1.68)	--	--	2.23E00 (0.42)	1.95E01* (2.28)	1.76E04* (2.27)	7.15E00 (1.41)	-6.69E01 (-1.66)	-1.00E01 (-1.28)	-6.33E04 (-0.67)	.9368

* - coefficient significantly different from zero at 5% level.
** - coefficient significantly different from zero at 6% level.

Units: P, EDEX, MUEX, EX, IGREV - $1000; YMED - dollars; MFGEMP - actual employment; HUNITS - actual number of units; BATHS - fraction x 100.

Data Sources: P - Massachusetts Department of Corporations and Taxation, <u>1976 Equalized Valuations of Massachusetts Cities and Towns</u>, April, 1977.
EDEX, MUEX, IGREV - 1976 <u>Census of Governments</u>.
HUNITS, BATHS - 1970 <u>Census of Housing</u>.
YMED - 1970 <u>Census of Population</u>.
MFGEMP - 1972 <u>Census of Manufactures</u>.
Other exogenuous variables in reduced form - <u>1970 Census of Housing</u>, <u>Census of Population</u>.

Footnotes

[1]Although no attempt is made to describe the political process by which public good levels are set, it is natural that z_1 and z_2 would increase with the income level of the community. This is a further reason to anticipate strong positive correlation among the arguments of R.

[2]The formulation (5) implicitly assumes that houses have infinite lives. Incorporating the effect on value of differences in remaining lifespans among houses would introduce severe complications.

[3]This discussion obviously ignores the different tax treatment of owner-occupiers and renters.

[4]When firms are realistically different from one another, the function π must be indexed by firm type. Now for a firm of type j to occupy a given structure of size s, it must be the case that $\pi^j(s,g) = \max\{\pi^i(s,g),\ i=1, \ldots, m\}$, where m is the number of firm types. Aggregate business property value becomes $\Sigma\pi^{f(s_j)}(s_j,g)/(\theta+\tau_1+\tau_2)$, where $f(s_j)$ equals the index of the firm type with the highest value of π for given structure. Since the subsequent analysis uses aggregate business profit gross of rent (Π) directly as an independent variable, the exact form of the expression which yields Π turns out to be unimportant. Thus, whether (8) or the more complex expression above is appropriate for determining aggregate value is immaterial for the purposes of the analysis. In addition, note that the local wage variable g, which will be related to the values of the y_i, is submerged in the variable Π.

[5]Since z_1 and z_2 are represented by education and other municipal services in the empirical work, the assumption of independent cost functions is realistic. For other pairs of public goods (fire and police protection, for example), the cost of providing a given amount of one public good could depend on the level of provision of the other.

[6]Note that the x_i in the last line of (16) are not held fixed as z_1 and z_2 vary but adjust according to the function t in (2) to keep utilities constant.

[7]Recalling that R is a strictly concave function of z_1 and z_2, it follows that $\sum_i R_{\ell\ell}(z_1,z_2,q_i;y_i) < 0$, which together with $C_{11}^{\ell} \geq 0$ implies $\partial^2 P/\partial z_\ell^2 < 0$, $\ell = 1,2$. Since concavity of R means that $\Sigma R(\cdot)$ is also strictly concave in z_1 and z_2, it follows that $\Sigma R_{11}\Sigma R_{22} - (\Sigma R_{21})^2 > 0$, which implies that $(\partial^2 P/\partial z_1^2)(\partial^2 P/\partial z_2^2) - (\partial^2 P/\partial z_1 \partial z_2)^2 =$ $\Sigma R_{11}\Sigma R_{22} - (\Sigma R_{21})^2 - C_{11}^1 \Sigma R_{22} - C_{11}^2 \Sigma R_{11} + C_{11}^1 C_{11}^2 > 0$.

[8] Although the analysis of Brueckner (1980) relates to a model where the only private production activity is housing production (so that a stock of business structures does not exist), an extension of the paper's argument would cover the case where each community has both business and residential structures. It also should be noted that satisfaction of the Samuelson condition within each community does not necessarily mean that the overall equilibrium of the community system is efficient (see Brueckner (1980)).

[9] A potential criticism of the Massachusetts sample is that communities are not all located in the same metropolitan area, making the assumption of uniform utilities within each income group difficult to accept. A response to this criticism is that the physical size of the state of Massachusetts is small enough so that the informational preconditions for arbitrage leading to uniform utilities are present. This argument ignores, however, possible short-run frictions due to job immobility among metropolitan areas, an impediment to mobility which does not arise when all employment is in the central city of one metropolitan area and selection of a community simply involves a choice of residential location.

[10] The change from public good levels to expenditures requires inverting the relationships $E_1 = C^1(z_1,n)$ and $E_2 = C^2(z_2,n)$ (the E_i are expenditures) to yield $z_i = \tilde{C}^i(E_i,n)$, $i = 1,2$. Equation (12) then becomes

$$P = P(\tilde{C}^1(E_1,n),\ \tilde{C}^2(E_2,n),\ Q,\ Y,\ \Pi,\ G_1,\ G_2)$$

$$\equiv \tilde{P}(E_1,\ E_2,\ Q,\ Y,\ \Pi,\ G_1,\ G_2).$$

Now since $\partial\tilde{P}/\partial E_i = (\partial P/\partial z_i)(\partial\tilde{C}^i/\partial E_i)$, where $\partial\tilde{C}^i/\partial E_i > 0$, the signs of $\partial\tilde{P}/\partial E_i$ have same efficiency meaning as the signs of $\partial P/\partial z_i$, $i = 1,2$. Although the discussion of the effect of the size of the housing stock (the dimension of Q and Y) on aggregate value changes somewhat, it is easy to see that holding E_1 and E_2 fixed, an increase in the size of the stock increases value when the z_i are pure public goods but that, as before, the effect is ambiguous when the z_i are congested.

[11] The source for regional district contributions was the 1970 Annual Report of the Department of Education of the Commonwealth of Massachusetts.

Appendix

Communities in Sample

Agawam**
Andover**
Arlington
Attleboro
Barnstable**
Beverly
Billerica**
Boston*
Brookline*
Burlington
Cambridge*
Chicopee
Dedham
Everett*
Framingham
Franklin
Gloucester
Haverhill
Hingham**
Holyoke
Leominster
Lexington
Lowell
Lynn
Malden*
Marlborough
Marshfield**
Medford
Melrose
Natick
Needham
New Bedford
Newton
Peabody
Pittsfield
Quincy
Reading
Revere*
Salem
Saugus
Somerville*
Springfield
Taunton
Tewksbury**
Wakefield
Waltham
Watertown*
West Springfield
Westfield
Wellesley
Weymouth
Wilmington**
Woburn
Worcester

* - Boston or inner suburb

** - rural township

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