Local Government Optimal Tax Rate: Lessons from the U.S. Cities

Arwi Srithongrung-Kriz, DPA
Associate Professor, School of Public Management and Policy University of Illinois-Spring field One University Plaza Dr. Springfield, IL 62703 USA

ABSTRACT: *This study uses the stochastic frontier analysis (SFA) approach to investigate (1) whether Samuelson's rule stating that optimal tax rate has marginal social cost equal to marginal social benefit is achievable by U.S. cities and (2) whether public factors can help the cities reach Samuelson's optimal level of tax rate. Data were derived from 69 U.S. cities from 2004 to 2012. The SFA results confirm that the efficient tax rate is achievable by some cities. Dynamic panel data results reveal that the public goods enhance efficiency for a city's tax and expenditure system. The implication is that in the U.S., public goods accumulated over time should be considered in setting the tax rate and determining whether the tax is too high or too low.*

KEYWORDS: *optimal taxation; efficiency; local expenditures; public goods; local taxation*

I. Introduction

In the United States, local government practitioners are seeking a way to keep the property tax rate relatively low, while at the same time providing the best possible local public services, including public infrastructure, safety, and education, to attract new businesses and residents. Based on Paul Samuelson's condition, an efficient public service level is the level in which the social marginal benefit of public service consumption is equal to the social marginal cost of public service provision (Samuelson 1969). This suggests that the optimal tax rate must correspond with the marginal level of public benefits, reflecting the true demands for public service in a jurisdiction.

Property tax is viewed as a benefit tax since a house with a greater square footage consumes more local public services, e.g., public safety and the fire service, than those with a smaller square footage, at least in a short-term analysis (Oates and Fischel 2016; Fisher 2007). Tiebout's theory assumes that new residents and businesses are mobile and will choose to relocate in a city whose government fiscal package (i.e., tax and service levels) correspond to their demands for local public services (Boadway and Tremblay 2012; Tiebout 1956). If Tiebout's process really occurs, then property tax is an optimal tax, reflecting demands for local public services.

However, public finance literature suggests that the Tiebout theory may not occur since moving is costly and households do not constantly adjust their housing consumption bundles (Boadway and Tremblay 2012; Wildasin 2012; Shan 2010). Furthermore, although Samuelson's condition is the best theory for the local optimal tax rate, its implementation may be questionable since there are other factors governing the decision for relocation in addition to local tax and public service level (Luque 2014; Wellisch and Hülshorst 2000). These factors include local public goods (or public factors heretofore) that accumulate over time and become productive factors that potential new firms and residents thinking about moving into the area take into consideration (Luques, 2014; Wellisch and Hülshorst 2000). Based on this, this article has a dual purpose: (1) to test whether Samuelson's optimal tax is achievable by U.S. cities and (2) to extend the theory by examining whether public factors play a significant role in helping a city to achieve the optimal tax rate.

In public finance literature, some challenges occur in testing the optimal property tax rate theory given that marginal social benefit cannot be directly observed and quantified. This is due to the fact that unlike private goods, public goods do not have an explicit market price. This study uses the concept of property tax capitalization defined by Yinger (1982) and Yinger et al. (1988) as a theoretical concept to measure marginal social benefit in reality. In practice, some studies, including those by Deller (1990) and Deller and Lledo (2001) use the property tax capitalization rate as a benchmark of the efficiency of tax rate setting.

This article is different than the existing literature in two ways. First, based on Samuelson's concept we first use the stochastic frontier analysis (SFA) technique to determine whether a city has an optimal tax rate. The SFA is a parametric procedure to identify and benchmark the efficiency of production units based on the relationship between inputs and outputs in the samples, and then estimating the inefficacy of each operational unit based on the benchmarks. To the best of the authors' knowledge, the SFA has not been used in property tax literature to benchmark the optimal property tax rate.

Second, for each municipality, the article compares tax rate efficiency measured by two concepts: the original theory by Samuelson and pure efficiency considerations of Wildasin (1986; 2012) and Wellisch and Hülshorst (2000) in which public expenditure is incorporated as another input in a city's financial management system. Then the article moves further to determine factors explaining the gaps between the two efficiency rates. Wildasin (1986; 2012) and Wellisch and Hülshorst, 2000 argue that on the cost side, efficiency of tax rate depends not only on the opportunity cost of tax collected, but also on the level of public expenditures and public amenities served to reduce firms' and labor production costs. By doing so, this article confirms a theory by Wildasin (1986; 2012) and Wellisch and Hülshorst (2000) that public factors (i.e., public spending to accumulate public amenities over time) can help local governments become closer to achieving their optimal tax rate compared to the ideal situation. The results suggest that the pure efficiency tax rate, in which public expenditure is considered as another input, is relatively more realistic than those of Samuelson's version. This finding is important to government practitioners in determining whether their local tax rates are relatively low or high, based on social benefits.

The article is organized as follows. The next section discusses the literature and proposes the underlying framework for the analysis. The third section provides testing models and discusses the SFA approach as a tool to obtain the efficiency rate of the samples. The fourth section presents the results. The final section provides the conclusion.

II. Literature

Conventional wisdom suggests that relatively high tax discourages the immigration of new residents and businesses, while relatively low taxes or no tax encourages their immigration (Brulhart, Bucovetsky and Schmidheiny, 2015). This is not necessarily the case, since local tax rates are not the sole factor determining new business and resident relocation (Brulhart, Bucovetsky and Schmidheiny, 2015; Luque, 2014; Wellisch and Hülshorst, 2000). According to Wellisch and Hülshorst's (2000) concept, in addition to private factors, such as land and labor prices, local public factors can influence the levels of tax rate. Shirotori, Tumurchudur, and Cadot (2010) define local public factors as an accumulation of changes over time that generate comparative advantages of a jurisdiction, and eventually create a pattern of relatedness of those productive factors across industries. Based on these authors' conceptualization of public factors, this article operationalizes the public factors concept by measuring the level of public spending accumulating over time; public spending is measured in different service functions, including spending on local public infrastructure, public safety, schools, highways. This section discusses the concept and measurement of the marginal social benefit of property tax, then provides the literature on the behaviors of local governments in setting their tax rates, and finally offers the theoretical framework for the article.

III. Marginal Social Benefit of Property Taxes

Efficient local property tax rate in Samuelson's condition is defined as the tax rate in which the marginal social benefits are equal to the marginal social cost for the tax paid by society (Due and Friedlaender 1973). In this respect, if local demand for public service is homogenous, then the local property tax rate perfectly reflects demands for public expenditure; the optimal tax rate is then determined by house size, which is similar across the jurisdictions. However, in the U.S., the Tiebout theory does not perfectly apply to local jurisdictions given that there is some heterogeneity in demand for public expenditure levels (Luque 2013; Konishi 2013; Boadway and Tremblay 2012;Gramlich and Rubinfeld 1982). This could be attributed to the fact that residents are not perfectly mobile and that the local governments may not be able to deliver a public service package targeting future residents due to limited information (Wildasin 2012; Boadway and Tremblay 2012; Shan 2010; Fisher 2007).

The immobility of residents is supported by economic development literature asserting that it is not only property tax rate but also job and production inputs, such as labor quality and transportation costs, that are important factors for the relocation of residents and businesses (Leigh and Blakely 2013). An economic development theory, location based, suggests that businesses are not freely mobile since some specific locations can reduce production costs – through better transportation and the accumulation of research, knowledge and technological development – more than other locations (Leigh and Blakely 2013). This theory explains why business conglomeration occurs in metropolitan areas and is opposed to the neoclassical growth theory asserting that labor and capital are freely mobile (Leigh and Blakely 2013).

To determine whether an optimal tax rate is achieved, the marginal social benefit has to be defined and carefully chosen. A marginal social benefit is a utility received by property taxpayers in exchange for consuming public services. In theory, the local public expenditure level can be an indicator for the utility based on tax price; however, an empirical evidence suggests that local public expenditure levels do not reflect the demand for public goods (and utilities) (Kim and Eom 2015). This is because some local governments, along with management institutions and special interest groups, control the public agenda (Kim and Eom 2015; Gramlich et al. 1973). Furthermore, when public service demands do not achieve the constant return to scale (Edminston and Spong 2012; Brown and Saks 1983), public expenditure is not an appropriate measure for the marginal benefit of the local property tax rate. Finally, since the Tiebout theory is not perfect, majority voting may not perfectly reflect the desired level of tax and expenditure in a jurisdiction where demands are heterogeneous.

IV. Housing Capitalization

Wildasin (2012) argues that capitalization is a better indicator than public expenditure to measure marginal social benefits the taxpayers receive in exchange for the taxes they paid. Capitalization refers to a phenomenon in which the taxes paid by homeowners is fully captured through the market value of a house in the present value term (Fisher 2007; Yinger, 1982). In the short term, demands and income heterogeneity may occur since small-house owners may choose to live in a large-house community simply to obtain better public services. However, in the long run, Fisher (2007) and Yinger (1982) argue that this phenomenon will create several demand shifts until the housing market reaches an equilibrium where a higher price for a small house is offset by low tax rates and the lower price for a large house is offset by the high taxes in the mixed community where both large and small houses coexist. When the equilibrium level is achieved, the capitalization process is fully completed.

V. Measuring Housing Capitalization

In this article, the above capitalization concept is chosen as an indicator for the marginal social benefits, given that the Tiebout process does not occur perfectly in the U.S. When capitalization is fully completed, even though the house sizes are different, the demand for public service levels are still homogeneous and is reflected through the market value of a house (Yinger 1982; Yinger et al. 1988). The completed capitalization means that property tax is a benefit tax in which each household pays the full cost of public service in its community (Fisher 2007, 113). In other words, property tax is fully capitalized if the value of a house is $1 lower whenever the present value of the stream of property tax payment on the house is $1 higher, all else being equal (Yinger et al. 1988). Yinger et al. (1988) thus conceptualize that property tax rate capitalization is the present value of a house captured through property tax rate over time. Accounting for the non-linearity of the relationship between the tax rate and housing value and social discount rate, Yinger et al. (1988) define the capitalization rate as equation (1).

$$mv = \frac{-\beta(\Delta t)}{i+\beta t_s} \quad (1)$$

where:
mv is the percentage change in the market housing value
t is the effective tax rate of property tax in a jurisdiction (total property tax paid/total housing market value)
i is the social discount rate.

Based on the capitalization concept, in this study, the percentage change in the present value of housing market value is chosen as social benefit based on the line of reasoning by Yinger et al. (1988) provided below:

> Consider a homeowner whose relative tax payment rises. Without capitalization tax changes affect the stream of tax payments but not the market price of the house, so this household can escape its higher taxes by selling its houses and moving to another location. With capitalization, on the other hand, tax changes are immediately translated into changes in the price of housing and this homeowner has no escape; either she stays in her house and pays for the higher stream of taxes or she sells her house and suffers the capital loss caused by the increased in the tax stream. Remember that with a discount rate of 3%, a $300 increase in the annual tax payment leads to $300/.3 =$10,000 decrease in the house value. With capitalization, therefore, modest changes in tax payments can lead to large gains and losses for current homeowners.
>
> Yinger et al. 1988, 7

VI. Government and Tax Rate Setting

When taken into consideration the effect of political voting by existing residents and fiscal zoning (i.e., a variety of existing household house values), Yinger (1982, 940) argues that property tax can be a distorted tax since government institutions and political agendas influence optimal tax levels. This line of reasoning contributes two implications. First, state and federal governments could reduce municipal tax rate distortion through block grant subsidy. Gramlich et al. (1973) and others (i.e., Crowley and Sobel 2011; Ermini and Santolini 2010; Revelli 2002; Buettner 2001) empirically found that federal and state block grants help subsidize the public service cost of a jurisdiction; and thus, reduce the property tax rate. Akin and Youngday (1976) prove that in New York, a state government grant can help increase property tax efficiency due to the demand heterogeneity of different income classes in a jurisdiction.

Second, heterogeneity in household characteristics should be taken into consideration when looking at optimization of the tax rate (Luque 2013). Median voters may not be the ones who set tax rates in such a heterogeneous community due to income and households heterogeneity. Using the Ricardian model, Palmon and Smith (1998) agree that the property tax rate distorts the housing market and the key is to find the optimal level of public services through demand heterogeneity. Gramlich and Rubinfeld's (1982) finding is also consistent with Palmon and Smith (1998), suggesting that per capita income is a better indicator for tax rates than median income since property tax is distorted by some specific groups who control public spending agendas. Thus, this analysis uses per capita income (captured through population and total personal income in the panel data estimation model) in investigating factors enhancing a city's fiscal efficiency.

In addition to the tax rate set based on average income and desirable public service expenditure, local public factors such as the accumulated public capital amenities and services may help optimize the tax rate (Wildasin, 2012). Wellisch and Hülshorst (2000) predict some patterns of local governments' behavior in setting the tax rate in order to achieve public service efficiency. First, in a jurisdiction where local property tax is relatively low but local public factors are relatively high (or have comparative advantage over other jurisdictions), the local government tends to set relatively high tax on firms and undersupply public services, which in turn indirectly limits households' inflows. This will eventually affect firms' production through labor supply. Second, in a jurisdiction where there is no direct firm taxes and local factors are also relatively low (or less competitive than other jurisdictions), the local government tends to set a relatively high tax rate on property (including residential and businesses) to restrict inflows of firms while at the same time oversupplying public services in order to accumulate public factors. Local public factors do not have a direct effect, but do have an indirect effect on the firms' profit through creating the size and quality of the local workforce by attracting quality households.

Based on the above observation, since there are no locally direct firm taxes in U.S. municipalities, local governments should act according to the second behavior: setting a relatively high property tax rate to accumulate public factors; and in this case, the optimal tax rate will not be achieved until public factors are sufficiently accumulated. This also implies that accumulated public factors are an important key in setting the tax rate. Based on this line of reasoning, the main hypothesis of this article is that local public factors are the key to helping a local government achieve its ideal situation in setting the optimal tax rate. Some cities may appear to have high tax rate compared to their housing value, however, it is possible that they are accumulating public factors in order to completely capture housing capitalization in the future.

Yinger et al. (1988) suggest that over time, the optimal tax rate is the rate in which the percentage change in an effective property tax rate is equivalent to the percentage change in the present value of the housing market value (MV). This relationship is shown in equation (2) below.

% Change of MV in Present Value = % Change of Effective Property Tax Rate---------(2)

Note that based on Yinger et al.'s (1988) concepts, a higher property tax rate results in lower housing values. However, because the tax rate is an effective tax rate instead of a nominal one, the concept that the property tax rate reduces housing value only reflects a reality that the housing market tries to capitalize housing values through heterogeneous demands.

In order to capture pure efficiency, public expenditure must be considered, given that in a heterogeneous housing jurisdiction, the local property tax rate does not perfectly reflect a socially desirable public expenditure level; hence, public spending level must be taken into consideration to understand the pure efficiency of the local property tax rate (Wildasin 2012; Yinger 1982). Oates and Schwab's (1997) analytical results suggest that public expenditure is important for a city development: if the local tax rate is not increased enough to cover public expenditure, other local taxes and fees tend to be increased to finance the necessary public services. Furthermore, empirical evidence suggests that not only an effective property tax rate, but also the levels of public expenditure influence housing value and such a relationship is an inverted U shape (Deller and Lledo 2001; Deller 1990). The pure efficiency of the property tax rate based on Wildasin (2012) and others (e.g., Deller and Lledo 2001; Deller 1990) is as shown in equation (3) below.

% Change of MV in Present Value = % Change of Effective Property Tax Rate + % Change in the Level of Public Expenditure-- (3)

The pure efficiency of the property tax rate through equation (3) reveals the true public service demand, which may or may not be consistent with property tax rate.

VII. Methodology

Stochastic frontier analysis (SFA) was used in order to analyze cost efficiency for a city based on its effective property tax rate. SFA was introduced by Aigner, Lovell and Schmidt (ALS) and Meeusen and van den Broeck (MB) in 1977. ALS and MB propose that parametric efficiency can be expressed as

$y = f(x; \beta) \cdot \exp\,[v - u]$ ---(4)

; where y is scalar output, x is the vector of inputs and β is a vector of technology parameters (Kumbhakar and Lovell 2000 14). The first error component $v - N(0, \sigma_v^2)$ captures statistical noise, while the second error component u captures the effect of technical inefficiency. Equation (5) below presents SFA using panel data.

$y_{it} = f(\mathbf{x}_{it}, \mathbf{z}_i) + v_{it} \pm u_{it}$; $\boldsymbol{\beta}'\mathbf{x}_{it} + \boldsymbol{\mu}'\mathbf{z}_i$ + vit $\pm$ u_{it}, ---------------(5)

; where

$y_{i,t}$ is change in housing market value for city *i* in year *t* as identified in equation (1)

$x_{i,t}$ is a vector of input including change in effective property tax rate for city *i* in year *t* and nominal discount rate as identified in equation (2). As mentioned in the literature section, total public expenditure was included in this vector for the pure efficiency analysis estimate through the second SFA

z_i is a vector of control variables such as time and city fixed effects

Thus, based on the definition of marginal social benefit defined through Yinger et al. 1988's concept shown in equation (1), the SFA model for this analysis is:

$\Delta LNMV_{i,t} = f(\Delta lneffrate_{i,t}, \Delta 1/i_{i,t}, z_{i,t}) + v_{i,t} \pm u_{i,t}$--------------------------(6)

where:

$\Delta LNMV_{i,t}$ is change in log of housing market value in real dollar value base year 2012 for city *i* in year *t*;

$\Delta lneffrate_{i,t}$ is change in log of effective property tax rate for city *i* in year *t*;

$\Delta ln(\frac{1}{i_{i,t}})$ is change in log of a fraction of nominal discount rate as provided by OMB- Circular A94 for the U.S. federal department. (This rate is used as social discount rate when federal agencies submit cost benefit analysis for the annually proposed capital projects.) According to equation (1), this variable entered SFA as an inverse ratio 1/i;

$v_{i,t}$ is statistical noise in the model;

$u_{i,t}$ is inefficiency based on mean value of best predicted efficiency;

z_i *is* the vector of control variables; given that the panel data is used in SFA, the vector of control variable z_i is comprised of unobserved time-invariant variable or fixed characteristics by each city.

Equation (6) was used in the first SFA as a base model. For pure efficiency analysis, change in the log of annual per capita public expenditure in real dollar value base year 2012 ($\Delta LNPCEX_{i,t}$) was added into equation (6) above for the second SFA analysis. The inefficiency scores for the base SFA model and the pure inefficiency SFA model (when public expenditure was added) was calculated and recorded as E_1 and E_2, respectively. The difference between E_1 and E_2 for each city in each year was calculated resulting in $IMPROVE_{i,t}$, which is *a path to pure efficiency* value derived by augmenting per capita public expenditure into the SFA base model (equation (6)).

Next, based on Wellisch and Hülshorst's (2000) model, accumulated public factors are the key factors to help local governments keep their tax rate efficient. Using a majority voting model augmented with grant, public school, highways, safety, and general public capital expenditure, the improved efficiency ($improve_{i,t}$) is determined by equation (7) shown below.

$improve_{i,t} = a + \beta_1 lnpop_{i,t} + \beta_2 lninc_{i,t} + \beta_3 cpi_t + \beta_4 unemp_{i,t} + \beta_5 lncap_{i,t} + \beta_6 lnschool_{i,t} + \beta_7 lnsafety_{i,t} + \beta_8 lnhwy_{i,t} + \beta_9 lngrant_{i,t} + \sum_{j=1}^{69} \beta_{10} M_t + \sum_{k=2004}^{2012} \beta_{11} T_t + \varepsilon$---(7)

where:

$improve_{i,t}$ is improved efficiency score (E_2-E_1) in city *i* at time *t*;

$lnpop_{i,t}$ is log of total population in city *i* at time *t*;

$lninc_{i,t}$ is log of total personal income in city *i* at time *t*;

cpi_t is consumer price index at time *t*;

$unemp_{i,t}$ is unemployment rate in city *i* at time *t*;

$lncap_{i,t}$ is log of public infrastructure spending in general public facility except school, safety and highway facilities accumulated overtime and depreciated at 4% per year in city *i* at time *t*;

$lnschool_{i,t}$ is log of local public school spending accumulated overtime and depreciated at 4% per year in city *i* at time *t*;

$lnsafety_{i,t}$ is log of public safety spending accumulated overtime and depreciated at 4% per year in city *i* at time *t*;

$lnhwy_{i,t}$ is log of local highways spending accumulated overtime and depreciated at 4% per year in city *i* at time *t*;

$lngrant_{i,t}$ is log of total intergovernmental revenue in city *i* at time *t*;

M_t is municipality fixed effect;
T_t is time fixed effect.

In equation (7), the model's dependent variable is improved efficiency ($improve_{i,t}$) instead of the pure efficiency score (E_2) because this exercise is focused on the pathway to local government's pure efficiency rather than on the simple efficiency score derived solely from property tax. In order to examine whether existing public factors accumulated over time can contribute to the pathway to local government efficiency, the variables accumulated public spending on general public facilities (except school, highway, and safety facilities) ($lncap_{i,t}$), school, safety, and highway ($lnschool_{i,t}, lnsafety_{i,t}, lnhwy_{i,t}$) were incorporated in the testing model (equation 7). These accumulated public spending were added in each year and depreciated at 4% per year to acquire a quantitative value of locally accumulated public factors. The 4% depreciation rate was chosen based on Holtz-Eakin's (1993) calculation for state and local public infrastructure depreciation rate. This is to understand what kind of public factors (i.e., general infrastructure such as city building and sewerage systems, school, highway and safety facilities) enhance efficiency for local government tax and expenditure. Intergovernmental revenue ($lngrant_{i,t}$) is included in the model to control for the effect of federal and state grants to equalize local governments across country and state, respectively.

VIII. Data

The data is derived from 69 cities in the United States from 2004 to 2012.

Table 1. Summary Statistics

	Mean	Std. Dev.	Min.	Max.	Obs.
<u>*Stage 1: SFA*</u>					
Effective tax rate (% to total MV)	16.3	33	0. 649	81	603
Nominal discount rate	2.78	0.417	2	3.5	603
Per capita real direct expenditure (real $ 2012)	6,395	2,427	3,030	20,973	603
Market housing value (nominal $, in million $)	2,911,738	5,355,735	12,571	4,110,000	603
Inefficiency score from Model 1 (E1)	3.45	3.70	0.67	49.99	603
Inefficiency score from Model 2 (E2)	2.94	3.70	0.34	50.28	603
<u>*Stage 2: PANEL DATA*</u>					
*Improved efficiency [((E2-E1) *100)) *-1] (%)*	16.4819	16.23	-46.25	85.23	603
Total population	573,534	1,057,782	152,799	8,273,130	603
Total income ($1000)	2,280,000	5,150,000	0	43,400,000	595
Consumer Price Index	1.147	0.068	1.027	1.2478	603
Unemployment rate	6.827	2.712	2.6	17.2	589
Accumulated public infrastructure value (nominal, in $1,000)	728,000	1,980,000	4,822.938	19,800,000	603
Accumulated public school value ($1,000, nominal, in)	1,160,000	2,720,000	178,000	24,000,000	603

Accumulated public safety value ($1,000, nominal, in)	474,000	1,080,000	57,100	8,760,000	603
Accumulated public highway value ($1,000, nominal, in)	133,000	301,000	57,100	8,760,000	603
Intergovernmental government grant ($1,000, nominal, in)	1,457,328	3,897,863	187,283	34,113,497	603

Table 2. Data Definition and Source

Variable Name	Definition	Source
Effective tax rate	Percent total property tax to total housing market value (MV)	Comprehensive annual financial reports
Nominal discount rate	Nominal discount rate for federal government agency used for cost-benefit analysis when proposing capital projects	Office of Management and Budget-OMB-Circular A94 Issued by U.S. Whitehouse
Per capita direct expenditure (real $ 2012)	Per capita direct expenditure (real $ 2012), calculated by total annual direct expenditure/total population	Lincoln Institute's city data
Market housing value (nominal $, in million $)	Assessed value (AV)*assessment ratio (AR)	Comprehensive annual financial reports
AV	Assessed valuation ($ millions)	Comprehensive annual financial reports
Ratio	Average assessment ratio	Comprehensive annual financial reports
E1	Inefficiency score from SFA Model 1 (the larger the value, the least efficiency)	Author's calculation
E2	Inefficiency score from SFA Model 2 (the larger the value, the least efficiency)	Author's calculation
Improved	Improved efficiency [(E2–E1)*100)*-1] (%); the larger the value, the more improved efficiency; positive number equals to better improvement, negative number equal to worsen efficiency	Author's calculation
lnpop	Log of total population	US Bureau of the Census
lninc	Log of total personal income	Lincoln Institute's city data
CPI	Consumer price index	US Bureau of Labor Statistics
unemp	Unemployment rate	US Bureau of Labor Statistics
lncap	Log of accumulated public infrastructure spending depreciated over time at 4% per year	Lincoln Institute's city data
lnschool	Log of accumulated public school spending value depreciated over time at 4% per year	Lincoln Institute's city data
lnsafety	Log of accumulated public safety spending value depreciated over time at 4% per year	Lincoln Institute's city data

lnhwy	Log of accumulated public highway spending value depreciated over time at 4% per year	Lincoln Institute's city data
lngrant	Log of intergovernmental government grant	Lincoln Institute's city data

Table 1 above presents summary statistics for the data used in Stage 1 and 2 analyses. Table 2 provides data definition and data source.

IX. Results and Discussion

The analysis was carried out in two stages: Stage 1: estimation for the cost efficiency of the 69 cities' fiscal package (property tax and expenditure) by SFA; and Stage 2: examination of whether public factors such as accumulated infrastructure, school, safety, and highway spending enhance efficiency through panel data analysis. In stage 1, the base model for SFA (equation (6)) was analyzed, resulting in the inefficiency score (E1) for each city. An inefficiency index equal to 1 means that a city has achieved cost-efficiency and is at the production frontier in producing public services using property tax. An index above 1 suggests inefficiency; there may be some resource slack for this city or the city might be accumulating public factors and has not reached its optimal point yet as suggested by Wellisch and Hülshorst (2000). An index below 1 also suggests inefficiency; the city may be suffering from scale economy problems (i.e., the government size is too small).

As shown in table 1 in the data section, the mean inefficiency score for E1 is 3.45, suggesting that on average the city samples carry resource slack in their fiscal package. This might also mean that the samples are accumulating public factors through high property tax rates compared to housing value (that has not been fully capitalized yet). Of 603 observations, 47 observations are at the frontier, 9 observations have scale economy problems and the rest are either accumulating their public factors or have resource slack problems. As shown in table 1, the minimum value for E1 is .67; while the maximum is 50. This suggests that some cities set the tax rate too low while others set their tax rate too high compared to market capitalization (or social benefit). Equation (6) was re-estimated through SFA again; but for the second time, $(\Delta LNPCEX_{i,t})$ was added into the model to achieve pure efficiency value since tax and expenditure must be altogether considered as the entire fiscal package.

Table 3. SFA Results for Pure Efficiency Analysis

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	| Mean of X|
Dependent variable	$\Delta LNMV_{i,t}$				
Primary Index Equation for Model					
Constant	-.365	.442	-.826	.409	
$\boldsymbol{\Delta ln(\frac{1}{i_{i,t}})}$	-.178	.034	-5.274	.000	5.222
$\boldsymbol{\Delta lneffrate_{i,t}}$	-.961	.006	-163.2	.000	.526
$(\boldsymbol{\Delta LNPCEX_{i,t}})$	.164	.039	4.217	.000	.252
Variance parameters for compound error					
Theta (Θ)	.196	.015	13.293	.000	
P $(\boldsymbol{\Phi}[\boldsymbol{L-\mu)/\sigma}])$, L is truncation point =0)	.574	.061	9.364	.000	
Sigmav ($\boldsymbol{\sigma_v}$)	5.095	.181	28.197	.000	

Limited Dependent Variable Model-Frontier; Estimated by Maximum Likelihood	
Number of observations	603
Iterations completed	16
Log likelihood function	-1963.347

Number of parameters	7
Info. criterion: AIC =	6.535
Finite sample: AIC =	6.535
Info. criterion: BIC =	6.586
Info. criterion: HQIC =	6.555
Normal-gamma frontier model	
Variances: Sigma-squared(v)=	25.959
Sigma-squared(u)=	14.892
Sigma(v) =	5.095
Sigma(u) =	3.859
Stochastic cost frontier, e=	v+u.

Table 3 presents the pure efficiency analysis results from the SFA. The coefficient of the effective tax rate is -0.96 and the coefficient for the discount rate is -0.18. Both coefficients are statistically significant at .01 level. The coefficient for the tax rate is almost equal to -1.00 suggesting that on average, capitalization is fully captured at the amount almost equal to a 1:1 ratio. The negative coefficient of the tax rate is as expected, since the tax is the cost for city public services production. The per capita expenditure coefficient is 0.16 and is statistically significant at .01 level. The effect of public expenditure is not large compared to those of property tax, but is strongly significant. As expected, the coefficient of public expenditure is positive, suggesting that producing public services is to add public factors to facilitate macroeconomic productivity in the city.

For variance parameters of the compounded errors shown in table 3, all statistics for the normal-gamma frontier model, including theta, P and sigma v $(\theta, P, and\ \sigma_v)$, are statistically significant. This suggests the model's goodness-of-fit for calculating cost-efficiency using the stochastic cost frontier model and normal gamma truncation as an assumption for maximum likelihood estimators. Gamma (γ), which explains the overall variance of the inefficiency explained by the model, can be calculated by $\frac{\sigma_u}{\sigma_v}$. Thus, gamma (γ) is 3.859/5.095 = .757. This suggests that approximately 76% of the model's variance is explained by the SFA model.

Based on the SFA results shown in table 3, the inefficiency score E2 for each city was calculated and recorded. As shown in table 1, the mean for E2 is 2.94, while standard deviation, maximum and minimum values are 3.7, .34 and 50, respectively. Of the 603 observations, 94 observations are at the frontier, 38 have scale economy problems and the rest either are accumulating the public factors or have resource slack problems. This suggests that the pure efficiency model is more realistic, since it allows more cities to achieve Samuelson's condition considering public expenditure as another input. A t-test was conducted to see whether the mean values of E1 and E2 are statistically different. The t-test results yield t-statistics equal to 2.617 for the difference between the two means with the p-value of the t score equal to 0.018. This suggests that the inefficiency scores E1 and E2 are statistically different and mutually exclusive.

Improvement for the efficiency path from basic to pure efficiency models was calculated by [(E2–E1) *100] *-1. Note that the improvement value (*improve*) is in percentage terms. The -1 value was multiplied to eliminate negative value since the majority of the samples have improvement; and thus, for convenience of interpretation the -1 is multiplied. The positive value of *improve* represents the better cost-efficiency achieved by spending tax revenue to produce public services and a negative value of *improve* means the opposite. As presented in table 1, on average, the city samples achieve 16.5% improvement through a tax and spending package. As also shown in table 1, standard deviation, minimum and maximum values for improved efficiency are 16.2%, -46% and 85.2%, respectively.

Next, the accumulated public spending on service functions necessary for economic development (i.e., general public infrastructure, public schools, safety, and highways) is individually examined in order to understand the kind of public factors helping a city government achieve property tax cost-efficiency. The disaggregated accumulated public spending entering the estimate model (equation (7)) is different from the per capita total expenditure entered into the SFA in stage 1 in that the disaggregated spending on public schools, safety, highways, and infrastructure was calculated as public stocks by accumulating the spending over years and applying straight-line depreciation at the rate of 4% per year. The depreciation rate of 4% per year is derived from Holtz-Eakin's estimation (1993) for state and local public infrastructure stock calculation. Thus, by this inventory accounting method, this public spending is equivalent to public factors as defined by Shirotori et al. (2000).

Equation (6) is estimated through the Arellano–Bover/Blundell–Bond dynamic panel data (DPD). The DPD is a system equation in which a lagged dependent variable is incorporated into the equation in order to correct autocorrelation. For the Arellano–Bover/Blundell–Bond estimator, the contemporaneous effect of the dependent and independent variables is captured by a moment condition in which the lagged level of the dependent variable is used as an instrumental variable for the first differenced equation, and the lagged differenced value of the dependent variable is used as an instrumental variable for level equation. The coefficients of the leveled variables represent the long-term effect of the model's independent variables (i.e., accumulated public spending or pubic factors) on the dependent variables (i.e., improve). The appropriate lag lengths for autocorrelation were chosen by information criteria statistics. The DPD model is used to correct endogeneity in equation (7) and to control for autocorrelation in time series data. The time and entity fixed effects were entered into the model.

Table 4. System Dynamic Panel-Data Analysis Results

Variable	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.Interval] Upper	Lower
Dependent variable: $improve_{i,t}$ (%)						
L1. $improve_{i,t}$(%)	-.087	.030	-2.91	.004	-.14636	-.02859
$lnpop_{i,t}$	-72.680	14.075	-5.16	.000	-100.268	-45.093
$lninc_{i,t}$	7.705	7.128	1.08	.280	-6.266	21.676
cpi_t	1.691	14.801	0.11	.909	-27.317	30.700
$unemp_{i,t}$	.305	.234	1.3	.192	-.153	.763
$lncap_{i,t}$	11.476	2.820	4.07	.000	5.950	17.003
$lnschool_{i,t}$	11.042	7.417	1.49	.137	-3.496	25.581
$lnsafety_{i,t}$	19.220	8.062	2.38	.017	3.419	35.021
$lnhwy_{i,t}$	9.006	2.402	3.75	.000	4.298	13.715
$lngrant_{i,t}$	-3.232	6.885	-.47	.639	-16.727	10.263
Constant	-151.186	93.951	-1.61	.108	-335.327	32.955
M_t Included						
T_t	Included					

System dynamic panel-data estimation, lags (1) two-step autocorrelation correction lag (2)

Group variable: id Time variable: year

Number of observation = 512 Number of groups = 66

Observations per group: min = 4 avg = 7.75 max = 8

Number of instruments = 45

Wald chi2(10) = 94.54 Prob > chi2 = .0000

Instruments for differenced equation
GMM-type: L(2/.).improve
Standard: Δ.lnpop Δ.lninc Δ.cpi Δ.unempl Δ.lncap Δ.lnsch Δ.lnsafe Δ.lnhwy Δ.loggrant
Instruments for level equation
GMM-type: Lagged Δ.improve

Table 4 presents the results estimated by equation (7). The DPD was estimated by using the 1-year lag of dependent (L1. $improve_{i,t}$). The first-stage analysis was estimated using the generalized method of moments (GMM) in which 2-year lag levels for dependent and independent variables were used as instrumental variables for differenced values of all variables in the model. The Wald-chi square 94.54 with probability chi-squared = 0.0000 suggests that the model passed the goodness-of-fit test. Robust standard error is used since the two-step GMM can generate biased standard errors.

The results in table 4 suggest that the lagged dependent variable (L1. $improve_{i,t}$) is necessary for panel-data analysis since the serial correlation exists. The coefficient of population (-72.7) is significant at .01 level. The negative and significant coefficient suggest that scale economy exists in determining the fiscal package (i.e., tax and expenditure package); namely, the larger a city, the more difficult it is for a city to set a tax rate and public expenditure level that can achieve cost-efficiency. All socioeconomic variables, including income, unemployment rate, and consumer price index are not statistically significant at the conventional level. This is possible given that the DPD captures these characteristics along with the two-way fixed effect (i.e., city and year fixed effects).

Most importantly, the coefficients of the accumulated public spending in various functions suggest the type of productive spending that can enhance pure efficiency for a local government's fiscal package. As shown in the table, productive spending includes public capital spending, safety and highways at coefficients 11.5, 19.2 and 9.0, respectively. The coefficients for capital and highway spending are statistically significant at .01 level and the coefficient for public safety spending is statistically significant at .05 level. For every 1% increase in real dollar value of public spending for infrastructure, safety and highways, a city can expect to see its fiscal package efficiency improve by 11.5%, 19.2% and 9%, respectively. These coefficients suggest that the effects of public factors on a city's pure efficiency is relatively large for all three types of services. This finding has particular application to the majority of samples that are inefficient due to slack resources: the governments can use resource slack (or property tax revenue) to invest in general public infrastructure, safety and highway facilities with better management skills and technical knowledge instead of cutting the tax rate if they have relatively low public factors.

As shown in the table, the coefficients for accumulated educational spending is not statistically significant at the conventional level. This is possible given that unlike highways, safety and other infrastructure, educated labors can be mobile. Intergovernmental government revenue is not statistically significant at conventional level; this is possible given that a grant is used to equalize the cities rather than to enhance the city's fiscal package efficiency.

X. Conclusion

The study examines (1) whether the optimal level of property tax rate can be achieved by the U.S. municipal governments using SFA to determine a city's fiscal management efficiency and (2) whether public factors in various service functions can help the city reach its optimal level of tax rate. Sixty-nine fiscally standardized cities were selected and used as data samples over 9 years. In order to measure the social benefit of property taxes, the article adopts the concept of housing capitalization, stating that property taxes and accumulated public spending were captured through market housing value over time, assuming that the homeowners do not sell their house to avoid taxes. The SFA results suggest that Samuelson's optimal tax rate is achievable by 94 out of 603 observations which is 15% of the samples; 38 observations or 6% are inefficient, since their property tax rate is too low relative to the benefit, capitalized housing value. The remaining 471 observations (79%) are inefficient due to slack resources suggesting that they should use slack resources to produce more public factors with better technical efficiency. The results from the second stage of analysis suggests that the public factors measured through accumulated public spending on public infrastructure, safety, and highways have significant and relatively large effects on the achievement of the optimal level of tax rate.

The study's finding contributes to theory and practice as follows. First, the findings expand the discussion on the property tax rate of local governments in that the empirical results suggest using SFA as another alternative approach to evaluate the tax rate's efficiency. Second, the extended theory that public factors are a simple but important key in helping a local government to enhance its efficiency was tested and confirmed: using public resources to invest in productive services such as infrastructure, sewerage, safety and highways is a way to enhance tax efficiency. For local practitioners, the level of public amenities as internal benchmark is often forgotten when considering whether their local property tax rate is too high. In practices, external benchmarks, i.e., other cities' tax rates, are used to judge whether a city has tax rate that is too high. This is not necessarily correct comparison since each city has different amount and types of public amenities and natural resource endowment contributing to comparative advantages that may be totally different than those of others. Nonetheless, this analysis is only one step on the road to understanding the optimal property tax and a strategy to improve tax rate efficiency. Further studies could find better evidence with different samples and loci.

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